HARNESSING CURIOSITY, INTEREST, AND EMPATHY IN THE COLLEGE CHEMISTRY CLASSROOM

BY

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DISSERTATION

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ABSTRACT

Freshmen and sophomores in college are historically at risk of disengaging with general and organic chemistry courses, performing poorly and not continuing in STEM. Utility value (UV) interventions, though, have increased the achievement and retention of low-performing students in psychology and introductory biology courses. In this study, a multi-semester UV intervention was implemented to increase curiosity, a predictor of increased learning and retention, of three student cohorts going through general and organic chemistry. Based on a preliminary analysis of Cohorts 1 and 2, students exposed to the multi-semester intervention perform a half letter grade better in introductory biochemistry after controlling for their ACT Composite and Math scores. Perhaps the most intriguing results from the FPIDC questionnaire is that the General Chemistry 2, Cohort 3 intervention resulted in a small positive effect on utility value of chemistry and moderate positive effect on interest in chemistry. These results contradict the earlier findings from the Epistemic Curiosity Scale results of General Chemistry 2, Cohort 2 which suggest that the PGX intervention had no effect on student curiosity and interest. The improved results in Cohort 3 are likely due to a major revision of the original General Chemistry 2 intervention. These results, therefore, support the notion that implementing new instructional methods in the classroom requires several iterations and revisions to be successful.

In 2017, a grad-roots movement started within the Chemistry Department at University of Illinois Urbana-Champaign (UIUC) with the assistance of psychology PhD student from UIUC Department of Clinical Psychology. Data was collected with the permission of the Department Head of Chemistry at UIUC and administered by graduate students from the Department of Chemistry Graduate Student Advisory Committee (DCGSAC). The data collected using this survey was compiled into a concise report, the Department of Chemistry Graduate Student

Wellness Report 2017 and posted throughout the halls of the UIUC chemistry department. In response to the publication of this report, the chemistry faculty organized, amongst other responses, a mandatory meeting to discuss the implications of this report. Graduate students in the chemistry department worked with the momentum that resulted from the Department of Chemistry Graduate Student Wellness Report 2017 to form a coalition of graduate student organizations in order to fund and organize the inaugural Summer Lecture Series directed at fostering a diverse and inclusive environment to support mental health and wellness within the Department of Chemistry at UIUC. This grad-roots movement toward mental health continues the arduous work of seeking expert guidance to promote mental health and wellness on campus and in graduate schools across the nation.

The findings described in Chapter 4 suggest that depression and anxiety may, at least in part, be the result of insufficient or nonexistent management training for research advisors. The unique relationship between mentors and mentees in a research university consists of a steep power dynamic which may instill a sense of impotence over graduate student's job control and may exacerbate preexisting mental health conditions. This work heavily influenced the author's previous perspective on undergraduate education and the influence that instructors have on their students' classroom engagement and mental health. This current chapter presents the need for empathic communication training for instructors of undergraduate courses, including gateway courses, such as introductory chemistry. A research plan is proposed for the development of a text classification tool for measuring and analyzing empathic communication in written assignments. Currently, the data collection for training this text classifier is underway.

The Kubler-Ross model (1969), which delineated the five stages of grief, and the SPIKES method (1992), which provided step-by-step instructions for recognizing and addressing the emotional states of patients, are two landmark publications that indicated the emerging need to prepare physicians to address the emotional states of patients. In 2015, the AAMC updated the MCAT to include a test section on social and behavioral sciences, reflecting the growing interest in preparing undergraduate pre-health students for the social and behavioral training in medical school. In previous research, an educational intervention in Organic Chemistry 1 and 2 required students to write journal entries reflecting a role-play exercise. This utility value intervention intended to increase the task value of organic chemistry by connecting students' academic tasks (studying organic chemistry) with their career aspirations (helping patients as practicing physicians). The goal of the research proposed herein is to analyze the text from these journal assignments to develop a proof of concept text classifier system able to recognize elements of empathy in text. Success of the text classifier will be assessed based on its agreement with human annotators of empathy in text. Further development of this text classifier will require data from medical school patient interview training and may lead to technology that will assist in consistently and objectively training future physicians to better address the emotional states of their patients.

“El mundo es de los atrevidos” – Alejandro “Atole” Alvarez

It has been 8 years since you were abruptly taken away from us. This page is for you, tio. I chose to begin this 11-year journey because of your influence. It has been, at times painful, at times rewarding. I think about you nearly every day. I hope you are proud.

ACKNOWLEDGEMENTS

Jeff, I honestly cannot express my gratitude for the privilege of working in your research group. I have the utmost respect for you, and I aspire to be as energetic and authentic as you are in every aspect of your life. Very few people have the honor of working with someone of your caliber. I love that you are hell-bent on making the world a better place through chemistry, materials science, education, and seemingly any avenue that you have access to. Before joining your research group in 2015, I had heard many stories about you from Phil Janowicz. Which, by the way, thank you Phil for letting me join your organic chemistry class way after the add deadline! Based on my conversations with Phil, I knew you were the type of leader that I wanted to be around. But watching you take the Moore Group motto, "It's all about the delta" into your work as Beckman director and as an undergraduate chemistry professor convinced me that you are 100% serious about making the world a better place by any means necessary.

Thank you Prof. Jennifer Cromley, Prof. Steve Zimmerman, and Prof. Wilfred van der Donk for your guidance and support as members of my committee. Jennifer, thank you specifically for your guidance into the field of educational psychology. I still remember quite vividly our conversations regarding my prelim. That was a challenging time for me, and I feel like a much stronger researcher (and person!) because I raised my standards and met the challenge head-on! Steve, I deeply respect and appreciate your dedication to promoting diversity and inclusion at UIUC. I appreciate everything you have done and continue to do for the chemistry community, especially meeting with the SWC to share your advice! Wilfred, thank you for your diligence as a member of my committee and for being a proponent of improving graduate student mental health and wellness!

Angie & Pepe, gracias por ser siempre mis padres carinosos. Angie, tu me ensenaste a navegar el universo sin miedo. Pepe, tu me ensenaste a seguir mi corazon. Los dos me ensenaron a amar de sus propias formas (muy distintas!!). I can't imagine having any other parents and I am very proud to be your son <3. Lalo, you have shown me to slow down and enjoy life, because it really isn't worth if you never stop to smell the roses. Kika, you taught me not to give a fruit to the people that do not matter. And Gooby, you taught me to listen carefully because everyone has something important to say.

I have been blessed with the opportunity to educate and encourage the bright young minds of K-12 students in the Champaign-Urbana area. I had this opportunity several times each year thanks to the support of Encouraging Tomorrow's Chemists. Thank you Kevin Cheng, Ian Robertson, Abby Halmes, Oleg Davydovich, Andrew Greenlee, Katie Stawiasz, and everyone who volunteered to help with the amazing ETC events over the years. There is an especially special place in my heart for the students and staff at the READY program. Working with READY students has been fulfilling for me because I also went to an alternative education center (Chino Valley Learning Academy, my continuation school <3) after I was expelled in my first year of high school. This was a formative experience for me in several ways, so I know it is a formative experience for the READY students. Most members of society have little or awful expectations of students, like me, that attend alternative education centers. Fortunately, ETC is run by fantastically optimistic graduate students that want to make the future a better place for everyone in it!

Misha, my beautiful golden boy! It has been such a pleasure learning and growing with you through my graduate school career and my mid-twenties. I consider myself to be an deeply optimistic person, but you, my friend, you are the fountain of youth. I respect your brilliance and

I love your generous, loving heart. I am lucky to be your friend. I look forward to the day when we're hanging out in our backyards, drinking beers, grilling steaks and watching our kids scratch their knees playing Pokémons and Dragon Dungeons. За здоровье y un abrazo, mi hermano!

Speaking of hermanos, Hector Lopez and Kenny Hernández-Burgos you two are a bloody riot!! Hector, you are one of my role models – I'm not even joking about that. I'm 10,000% serious and you know I am because I snapchat you from time to time just to tell you. Kenny, eres un hermano mio y tus buenas vibras alimentan mi corazon. Cuando me siento con mi gente para beber una buena fria, mi recuerdo de nuestro tiempo en PA. Eso es vida!

Dr. José Andino! You have been a great role model for me (and so many other students that I have spoken with!) since my first year of graduate school. I admire your passion for teaching and nurturing your relationships with your students. I appreciate your support of my professional development from working with me on my research project to inviting me to mentor students through La Casa and inviting me to serve as a micro-teaching facilitator for incoming graduate TA's. Whenever I think of wat my life would be like if I were to have the honor of becoming a college chemistry educator, I think of you.

Dr. Christian Ray! I cannot thank you enough for your multifaceted support throughout my time here at Champaign-Urbana. I have stolen several elements of your lecturing style and incorporated them into my own style. Exhibit A being my intro slides on day one of every lecture! Watching you talk about your family and yourself during that first day of lecture is an excellent way to begin building trust with your students from the start of the semester. I have instilled that value into all my TA's and co-lecturers by having them also introduce themselves on day one in a similar way. And, this probably goes without saying, I have always admired your leadership and natural conversational ability. I have never told you this before, but I try to emulate your conversational warmth in my own professional relationships.

There is a special place in my heart for Ceci Gentle and the W&W Guild. Ceci, I said this during our first year of grad school and I have felt the same way throughout our graduate school career – I love your genuine curiosity about the world! I think we both have had really weird, interesting, and ultimately rewarding career paths in graduate school. I have enjoyed learning and living through this experience alongside you. I am especially thankful that you founded the W&W Guild. It helped me stay focused on writing my dissertation before the quarantine and it *really* helped me stay focused during the quarantine. The first week of living underground was especially rough and W&W was right there to help me keep pushing. May we continue to forge unique paths in the future!

I would like to thank Conner Dykstra for welcoming into the world of bouldering and climbing. When you first invited me to Urbana Boulders (UB) I was struggling to get myself out of my sluggish routine. I had a great time pushing my limits by pulling myself up a wall twice a week! I have been climbing for 10 months now which has strengthened my discipline and improved my wellbeing! I made great friends at UB and the climbing wall at the ARC – all thanks to you!

I need to thank Joe Peterson for all the lunches at Scotty's and the great conversation. I absolutely love a deep conversation regarding the beauty and difficulties of Nature and the State. Before my uncle passed away, I would spend hours talking with him about anything and everything at great length and in excruciating detail. I was incredibly grateful to have met you and engage in conversations like the ones I used to have with my uncle. I look forward to having many more conversations with you in the future!

Joe Nugent and Suds Dwaraknath – you two are a fraternal blast. I'll never forget any of our adventures into the center of the maze. I loved exploring seeking out my fears and inner peace with you. I am very grateful to have spent the past 5 years with you both. Joe, you and are polar opposites on several dimensions and, honestly, at first it frustrated me beyond reason. But, over the past 5 years I have learned to appreciate and embody some of your best practices to make myself a more well-rounded person. Suds, you are more extreme than I am on several dimensions. Over the past 5 years I have learned to push myself further along those dimensions and I hope I have the energy to continue challenging myself well into the future. You two are my yin and yang, my ebb and flow, my this way that way. I am super into it and very grateful.

Oooo, baby I love your way! Gabe, how do I begin to thank you for arguing about pedagogical methods with me?? You became a significant portion of my formative experience here at University of Illinois Urbana-Champaign. Teaching with you for three years was a great experience. Singing in BrewLab every morning while we worked on creating an engaging educational experience for our students is among my fondest memories of my entire life. The contrast between our styles was a nurturing environment for my current teaching style. I still catch myself executing some of the Gabe mannerisms that I picked up from watching your lectures. But wait, there's more! Even after you began your career at Eastern Michigan University, we continued discussing pedagogy! I am excited to see where our friendship and our professional careers lead us in the future! I think Pablo Neruda was thinking about our blossoming friendship when he wrote, "Peace goes into the making of a poem as flour goes into the making of bread."

On that note, I must give a special thank you to Tim Chao, Gabe (from BrewLab), Christian Murphy, Linn, and the rest of the stellar BrewLab staff. I have spent countless hours

taking up space in your lovely, adorable, cute af, and welcoming establishment. I spent at least three days each week for a good two years in your coffeeshop. A conservative estimate is that I have had 300+ cups of coffee thoughtfully prepared by your amazing staff. I have loved each and every cup! I never thought I would learn to appreciate and distinguish a good cup of coffee from a cup of coffee trying its hardest with the cards it was dealt. The little bit I have learned about coffee during my PhD program I can happily attribute to you! I always wondered how much I was pushing my welcome by having so many of my office hours and book club meetings within the confines of your busy coffee shop. I may never know the answer to that question if this pandemic remains in place after I defend, but I hope I was slightly more of a pleasant experience than a bother!

Troy, on the day of my defense you were on week 209 of your taco tour. Those taco snaps fed my soul and whet my appetite. I aspire to be as saucy as you are. I am living for the day when we finally get to deliver our comedy routines at Clark Bar or Soma, or wherever we get the chance to have an audience full of mostly our friends but also some other people. It's going to happen man. Trust the process.

Thank you to every contrarian that blocked my path and doubted me along the way. You were many, and you were all fuel to the fire that kept me going. Swerving your negativity and climbing over your obstacles was a great core workout. You shall not be named and all but your silhouettes will be forgotten.

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Puppy posse: Tabitha, Oakley, Kelly, Vinnie, and Brisket! Oh, all the heckin' romps and frolics our puppies have enjoyed at the bark park! Great memories all of them! Honestly, when I first adopted a puppy, I thought to myself, "Holy shit, Jose, you have done it again! You chose to live your life instead of focusing on work! Now you will fall behind in work and everything will be for naught!" Much to my delight, having you two as fellow puppy parents assuaged my ridiculous concerns and reinforced the playful puppy attitude I have toward life. Thanks!

My students! What a magnificent group of students I have had the pleasure of meeting! My love of research has ebbed and flowed over the years. This is a natural part of the process; it is to be expected in any PhD program. But learning with my students has always been one of the best experiences of each week I spent in Urbana-Champaign! There are so many of you to mention and each relationship has been unique and beautiful in its own way. I would have to write a whole other dissertation to thoroughly catalogue and explain the wonderful things about each student I have learned with! Instead of doing that, I will continue to stay in touch with you as you progress through your own careers. My favorite part of teaching has always been watching the oak trees grow!

Brisket! I love you, my little piggy <3. Even though your birth parents are no longer with us, I am sure they would be proud and overjoyed to know that you are a bright, strong, and healthy young lady. Yes, I filled out the adoption paperwork and drove you to our loving home, but you are the one that rescued me. I cherish all my memories with you. I cherish all the ‘bad’ memories I have had with you because they revealed to me my stressors, fears, and negativity. I cherish all the good memories with you because they fill my heart with joy and happiness.

A message to the Trash Dogs in the sierra of northern Michoacán. I am not sure if I will ever have the pleasure to meet you, and if I ever do, I am not sure it would be in either of our best interests. I hope you know that there are people, real human people, worlds away from you that are rooting for you. We see ourselves in you. We do not know if there is a happy ending in your future, but we hope that you do find a happy ending in your story.

Cody Breitenfeldt, a fellow wordsmith. I keep my memories of your expertly crafted storytelling very close to my heart. Far too few people will the pleasure of meeting you in person, but your spirit lives on in the hearts of all your friends and continues to make the world a better place. In fact, you inspired a significant portion of my research into emotional health. We pour one out for you every time we float down Sugar Creek.

Thank you to Summer Laffoon, Alison Wallum, Marina Philip, Lauren Hagler, Brenda Andrade, Kimberly Bassett, Lloyd Munjanja, everyone involved with SWC, and many others for your support in making our little corner of the world a better place. We have different perspectives, but we’re all looking ahead at a better tomorrow.

The list of people that have influenced me during my grad school career is far too long to list in full. While their names may not be listed in writing, they are engrained in my heart and I carry you with me everywhere I go. Thank you.

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CHAPTER 1: CHALLENGES OF COLLEGE CHEMISTRY IN THE 21ST CENTURY

"We are used to thinking of doctoring as a solitary intellectual task. But making medicine go right is less often like making a difficult diagnosis than like making sure everyone washes their hands" – Atul Gawande, Better: A Surgeon's Notes on Performance

Abstract:

General and organic chemistry are comprised of a relentlessly growing body of abstract concepts that are often taught in a highly decontextualized manner. Building intuitive mental models to construct meaning from chemistry content is further complicated by the multiple representational levels of chemistry, such as the macroscale world that can be seen with the human eye, the microscale world that requires chemical instrumentation to be observed, and the semiotic world made of multitudes of highly specific symbols to represent molecules and molecular interactions. Meaningful learning within a given discipline exists near the intersection of rote learning information about the discipline and using analogical reasoning to build deep learning that can be transferred to any discipline. When students engage in meaningful learning, they are using critical reasoning and previous experiences to make connections between new content knowledge in a given discipline. Creating a meaningful learning experience is the task of the instructor. A savvy instructor can seek out evidence-based instructional practices to implement in their classroom to cater to the specific needs of their course and student population. However, once a meaningful learning environment has been created, the students must ultimately make the decision of choosing to engage in meaningful learning. While this decision relies heavily upon the student's valence toward the given course, this decision may be swayed using

targeted interventions to emotionally engage students and motivate them to spend the effort to adopt effective study habits. The research into targeted motivation intervention that call upon students' curiosity and interest have been shown to have some success in biology, psychology, engineering, chemistry and other courses. Developing targeted interventions such as these may be a promising avenue for preparing myriad students of diverse backgrounds to succeed in introductory chemistry courses.

Challenges of Teaching, Learning, and Reforming Introductory Chemistry:

This thesis will focus on the challenges of fostering meaningful learning in the introductory chemistry classroom of the 21st century. The challenges focused upon in this thesis regarding introductory college chemistry will revolve around the unique difficulties of general and organic chemistry courses. Second, it is important to consider the education research revolving around harnessing motivation in the classroom that may provide insight into how best to surmount the motivational drain imposed by the decontextualized nature of contemporary college chemistry. Third, it is also important to consider the barriers to reforming introductory chemistry education to include evidence-based instruction. Fourth, it is important to consider the greater collegiate context in which introductory college chemistry students exist and the challenges that the college environment can pose for college students.

General and organic chemistry courses are traditionally difficult courses usually taken by freshmen and sophomores.[1] Students in these courses are at risk of performing poorly if they disengage with the course and not continuing in chemistry.[2,3] Part of what makes learning chemistry difficult is the density, frequency, and abstract nature of chemistry concepts presented in quick succession to chemistry students beginning at the high school level.[4] Building intuitive mental models to construct meaning from chemistry content is further complicated by the multiple representational levels of chemistry, such as the macroscale world that can be seen with the human eye, the microscale world that requires chemical instrumentation to be observed, and the semiotic world made of multitudes of highly specific symbols to represent molecules and molecular interactions.[5,6] Chemistry education has evolved a great deal since the construction of Noyes Laboratory over 100 years ago[7].

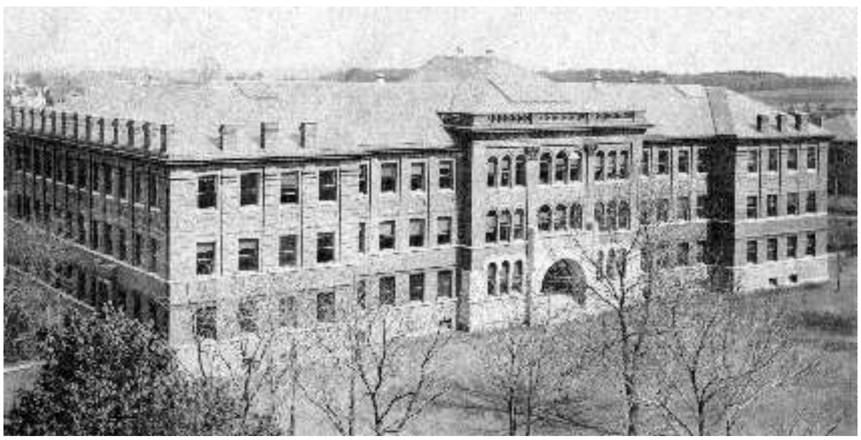

Figure 1.1. The original structure of the building that would become Noyes Laboratory was an "E" shape and was completed in 1902. With World War 1 on the rise fueling the development of the American chemical industry, William Noyes secured funding to double the size of Noyes Laboratory and in 1915 gave it the hollow square shape that it has today.

Likewise, research in chemistry education has evolved over past century, through the long and continuing period of personal empiricism and into the last half century of rigorous research.[8] A wide variety of discipline-specific educational research exists, covering active learning instructional methods in lecture and laboratories,[9–11] curriculum redesign to prepare chemistry students for 21st century problems,[12] change management for reforming faculty instructional practices,[13] and motivation in the classroom.[14] This document will focus on harnessing motivation in the introductory college chemistry classroom by contextualizing and facilitating student connections with course content.

Many educators would agree the goal of a college education is to prepare students for the problems they will encounter beyond their college careers. In order to accomplish this goal, educators should aspire to engage their students in meaningful learning so they may take relevant information and critical reasoning skills into their professional careers. Meaningful learning can be described by the intersection of skill transfer and factual recall as shown in Figure 2.[15,16]

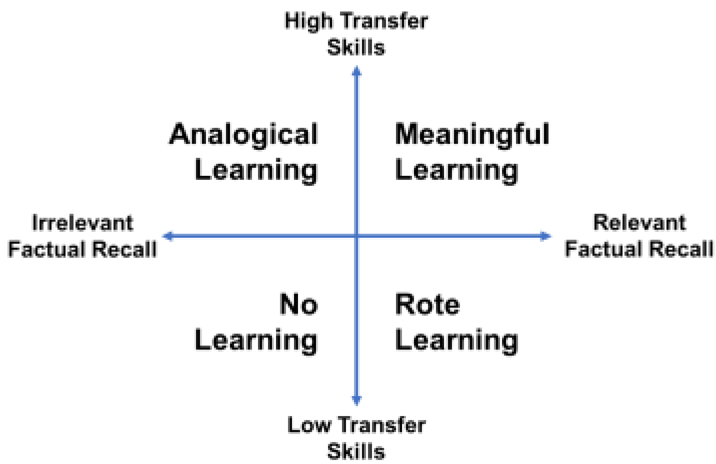

Figure 1.2. The dichotomy of rote/meaningful learning as described in *Discipline-Centered Post-Secondary Science Education Research: Distinctive Targets, Challenges and Opportunities.*

To understand the dichotomy of rote versus meaningful learning, consider for example, three hypothetical Algebra I students named Flora, Dora, and Zora. Flora learned to recall relevant facts and analogical reasoning for solving any given Algebra I problems, Dora learned only to recall facts and algorithms for solving Algebra I problems, and Zora learned only analogical reasoning skills for solving Algebra I problems. In this hypothetical scenario, Flora has engaged in meaningful learning that will allow her to apply her factual knowledge and analogical reasoning skills to new problems in Algebra II. However, Dora will struggle to identify where and how to apply her Algebra I factual knowledge in Algebra II problems and Zora may use her reasoning skills to identify where and how to apply her knowledge but will lack the ability to recall relevant information to solve new problems. Of course, a college chemistry educator that is intent on creating a learning environment that facilitates and encourages students to engage in meaningful learning can begin by reading through related articles from the *Journal of Chemical Education* or the journal of *Chemistry Education Research and Practice* in search of evidence-based instructional practices that will foster meaningful learning. Ultimately, of course, the decision to engage in meaningful learning must be made by the autonomous students in college chemistry courses.[17] However, it may be possible to emotionally predispose, or motivate, a student to choose to engage in meaningful learning by affecting their curiosity and interest in course content.

According to Eccles' Expectancy Value model,[18] academic and achievement-related decisions are rooted in a student's expectancy to succeed at a given task and the student's perceived value of succeeding at that task. For example, a pre-medical student that has high expectations of success in chemistry may choose to pursue a Chemistry minor in addition to their Molecular and Cellular Biology major. This same pre-medical student with high perceived task value in succeeding at chemistry may decide to take the course Drug Development and Discovery at UIUC as part of their chemistry minor to support their future career as a medical practitioner. Students' task value has been found to have a positive correlation with academic achievement in introductory college chemistry (zero-order correlations = 0.21 – 0.30, $p < 0.001$).[19] Task value can be broken down into three subfactors, attainment value, utility value, and interest value.[20] Attainment value refers to the perceived value that a task has for the student's identity. For example, a student that perceives themselves as a physician-to-be may believe that knowledge of the FDA drug approval process is something that a good medical practitioner should have. Utility value refers to a student's perceived usefulness of a task to their future career. For example, a student may believe that a strong grasp of drug design will be advantageous to succeeding in medical school. Interest value is a student's perception of the inherent pleasure of accomplishing a task. For example, a student may believe that drug discovery and design is incredibly fascinating regardless of its potential to benefit them in their future career. Previous intervention studies have found that utility value (UV) interventions are capable of increasing retention and achievement of students in algebra, introductory psychology, introductory biology courses, engineering courses, introductory physics, and introductory chemistry courses.[21–27] If instructors present chemistry course content in a personally meaningful way, it may be possible to increase retention of low performers in chemistry and increase achievement of low performers in chemistry. Curiosity and interest were studied for their potential to generate and foster personal meaning and harness motivation in the college chemistry classroom. *Epistemic Curiosity* consists of two factors, Deprivation-type (D-type) and Interest-type (I-type) curiosity.[28] D-type curiosity may be understood as the desire to answer a specific question triggered by the awareness of a knowledge gap.[29] I-type curiosity may be understood as the desire to learn more about a subject because of the pleasure derived from knowledge of that subject. *Interest* is perhaps better illustrated and understood with Hidi and Renninger's Four-Phase Model of Interest Development (FPID).[30] In this model, *interest* is defined as a motivational variable that predisposes students to engage and reengage with particular classes of objects, events, or ideas over time. Interest is something that can be caught (first two phases) and held (second two phases) as students develop their interest over time.

Together, curiosity and interest may drive students to formulate their own questions and take ownership of their learning experience. Therefore, it is critical to identify instructional practices that can help educators harness epistemic curiosity in the classroom. Developing curiosity and interest is expected to strengthen student motivation to spend more quality time and effort studying chemistry, thereby improving their academic performance.[31–33]

College chemistry students most often exist within the spatial and temporal context of a physical college campus. Therefore, the influence of external factors that exist outside the confines of the chemistry classroom but inside the vague boundaries of the college campus must also be considered. External factors such as a student's socioeconomic background, family history, or global pandemics may originate outside of the classroom, but they can permeate deep into the walls of college classrooms. While it may easy to consider the process of learning strictly a cognitive journey, students' emotional states in the classroom play a significant role in facilitating or preventing students' ability to focus and learn effectively.[34] Consider, the effect of a student's emotional state on their ability to self-regulate their academic performance. If a student has low self-efficacy, ability to exercise control in coping with different situations,[35] they may be more heavily affected by turbulent external factors that originate outside of the chemistry classroom.[36] Moreover, Eisenberg's longitudinal study from the United States found that poor mental health can negatively affect academic success and, worse yet, the stigmatization of mental health prevents many college students from seeking out helpful resources.[37] Consider, for example, the current COVID-19 pandemic of 2020, when nearly every university in America had to switch to online classrooms overnight. Not only were instructors caught off guard with this switch, but students, also, were required to shelter in place. Many students had to leave their dorms and return home, unsure of whether their housing situation would be reimbursed. Our nation will have to wait for case studies and research on the emotional processing of the pandemic, but news articles have already begun discussing what is considered mass grieving among the populace.[38] Remote classrooms also present unique challenges. Online learning is improving and it affords more accessibility in some scenarios, but it also presents new difficulties.[39] While some online challenges may be circumvented with due diligence in preparing for the online environment, in some cases instructors do not have the privilege of preparing themselves and their courses for the online setting. At the time this dissertation was written, the citizens of planet Earth have found themselves in the middle (or, most likely, merely at the beginning) of the COVID-19 pandemic. This must also be considered and is a worthwhile avenue of research and design that should be considered for future generations of students and teachers.[40–43]

Conclusion:

Introductory chemistry, due to its abstract and decontextualized delivery in college courses, is a challenging gateway in college that compels college students to make the difficult decision of staying or abandoning a STEM degree. Reforming college chemistry education is, historically and contemporaneously, a long and arduous process, with a variety of obstacles to be overcome. As educators, administrators, and policy makers work to adjust educational policy, they should pay close attention to the growing body of chemistry education research and evidence-based instructional methods, adhering closely to the specific meanings of educational terminology.[11] In addition to the reform that must be undergone within the confines of the remote or physical chemistry classroom, careful attention must also be paid to educational policy regarding the external factors that permeate into the classroom, such as the prevalence and sources of depression and anxiety amongst college students.

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CHAPTER 2: MOLECULAR SCIENCES MADE PERSONAL

"You will never be able to escape from your heart. So it's better to listen to what it has to say."

– Paolo Coelho

Abstract:

Freshmen and sophomores in college are historically at risk of disengaging with general and organic chemistry courses, performing poorly and not continuing in STEM. Utility value (UV) interventions, though, have increased the achievement and retention of low-performing students in psychology and introductory biology courses. In this study, a multi-semester UV intervention was implemented to increase curiosity, a predictor of increased learning and retention, of three student cohorts going through general and organic chemistry. Based on a preliminary analysis of Cohorts 1 and 2, students exposed to the multi-semester intervention perform a half letter grade better in introductory biochemistry after controlling for their ACT Composite and Math scores. Perhaps the most intriguing results from the FPIDC questionnaire is that the General Chemistry 2, Cohort 3 intervention resulted in a small positive effect on utility value of chemistry and moderate positive effect on interest in chemistry. These results contradict the earlier findings from the Epistemic Curiosity Scale results of General Chemistry 2, Cohort 2 which suggest that the PGX intervention had no effect on student curiosity and interest. The improved results in Cohort 3 are likely due to a major revision of the original General Chemistry 2 intervention. These results, therefore, support the notion that implementing new instructional methods in the classroom requires several iterations and revisions to be successful.

Introduction:

General and organic chemistry courses are traditionally difficult courses usually taken by freshmen and sophomores.[1] Students in these courses are at risk of performing poorly if they disengage with the course and not continuing in chemistry. According to Eccles' expectancy value model,[2] academic and achievement-related decisions are rooted in student's expectancy to succeed at a task and student's perceived value of succeeding at a task. For example, a student that has high expectations of success in chemistry may take more chemistry courses. A student with high perceived value in succeeding at chemistry may spend more time practicing chemistry problem sets. Students' task value is known to be a predictor of student achievement in introductory college chemistry.[3]

Previous intervention studies have found that utility value (UV) interventions are capable of increasing retention and achievement of students in many different introductory courses, including but certainly not limited to introductory psychology, introductory chemistry, and introductory biology courses.[4–6] If instructors present chemistry course content in a personally meaningful way, it may be possible to increase retention of low performers in chemistry and increase achievement of low performers in chemistry.

The goal of this study was to test the following hypothesis: making chemistry personal enhances curiosity, interest, and student learning. In this study, chemistry was made personal for students by (1) offering students 23andMe kits and teaching them to analyze their genome so they could visualize how chemistry principles affect their own genetic expression and (2) letting students role-play as physicians to explain chemistry principles to their hypothetical patients.

Harnessing Curiosity to Motivate Learning:

Curiosity is an emotion commonly described as the desire to seek out and experience novel stimuli.[7] Animals and humans are capable of exhibiting curious behavior, such as chimpanzees investigating grass-fires[8] and infants pointing at novel objects.[9] In many cases, animals and humans express their curiosity toward the novel stimulus through actions which can be described as exploratory behaviors.[10] In addition to this exploratory curiosity, humans can also express curiosity for new knowledge as we often do in classroom environments or while surfing the internet. This type of curiosity is termed epistemic curiosity and was described by Berlyne as a “drive to know” more and gather knowledge.[11] Epistemic curiosity is a peculiar emotion, as it can be characterized as a flurry of a dash of fear, a little bravery, and a strong desire to answer a specific question. In the chemistry classroom, inciting epistemic curiosity might drive students to ask deeper questions in chemistry.

The Epistemic Curiosity Scale used in this study describes epistemic curiosity as consisting of two parts, Deprivation-type (D-type) and Interest-type (I-type) curiosity.[12] D-type curiosity may be understood as the desire to answer a specific question triggered by the awareness of a knowledge gap.[7] For example, an instructor might start a lecture on molecular orbitals with a chemistry demo where various materials are placed by a strong magnet and ask students which materials they expect will be magnetic. Based on their experiences with magnets, most students will likely answer that metallic objects such as paper clips and nails will be attracted to the magnet. Then, the instructor might carefully pour liquid oxygen between the two polarities of the magnet drawing attention to the fact that the liquid oxygen is also magnetic. By demonstrating the magnetism of oxygen, the instructor has shown students that not all magnetic materials are metals and thus exposed a gap in their knowledge about magnetism! The instructor can then harness this D-type curiosity to lead students into a discussion of molecular orbitals, unpaired electrons, and paramagnetism. I-type curiosity may be understood as the desire to learn more about a subject because of the pleasure derived from knowledge of that subject. For example, a student that was particularly fascinated by the explanation of unpaired electrons and paramagnetism, may continue to pursue more knowledge on these subjects. This student's quest for knowledge may eventually lead them to the Wikipedia article on magnetoreception. If the I-type curiosity is strong enough, the student may even search for one of Klaus Schulten's research articles on the proposed mechanism of magnetoreception in birds![13]

Together, D-type and I-type curiosity may drive students to formulate their own questions and take ownership of their learning experience. Therefore, it is critical to identify instructional practices that can help educators harness epistemic curiosity in the classroom. Developing curiosity and interest is expected to strengthen student motivation to spend more quality time and effort studying chemistry, thereby improving their academic performance.[14–16]

This study, as shown below, began with Cohort 1 in Spring 2016 and was followed by Cohorts 2 and 3 in Spring 2017 and Spring 2018, as shown in Figure 2.1. Each Cohort experiences a multi-semester intervention applied to their General Chemistry 2 (G2), Organic Chemistry 1 (O1), and Organic Chemistry 2 (O2) courses. The multi-semester intervention consists of a semester-long group research project in G2 and artistic journal entries in O1 and O2, which will be explained in further detail below. Effects of the multi-semester intervention are measured based on exam score comparisons in G2 and O1; overall course performance in Introductory Biochemistry; self-reported questionnaires of student curiosity and interest in G2, O1, and O2; and focus groups during the spring semester immediately following completion Introductory Biochemistry.

The course enrollment and interventions applied in each semester are shown in Table 2.1. Each cohort, as shown in Figure 2.1, consisted of one experimental class of G2, three control classes of G2, one experimental class of O1, two control classes of O2, one experimental class of O2, and two control classes of O2. For example, Cohort 1 began in Spring 2016 with 330 students in the single experimental class of G2 and 900 students in the three control classes of G2. In Spring 2017, there were 70 Cohort 1 students in the experimental O2 class and 600 students in the two control O2 classes. The interventions were applied only to the experimental classes. All students in the experimental classes were required to complete the intervention assignments. There was no intervention applied to the Intro Biochemistry courses.

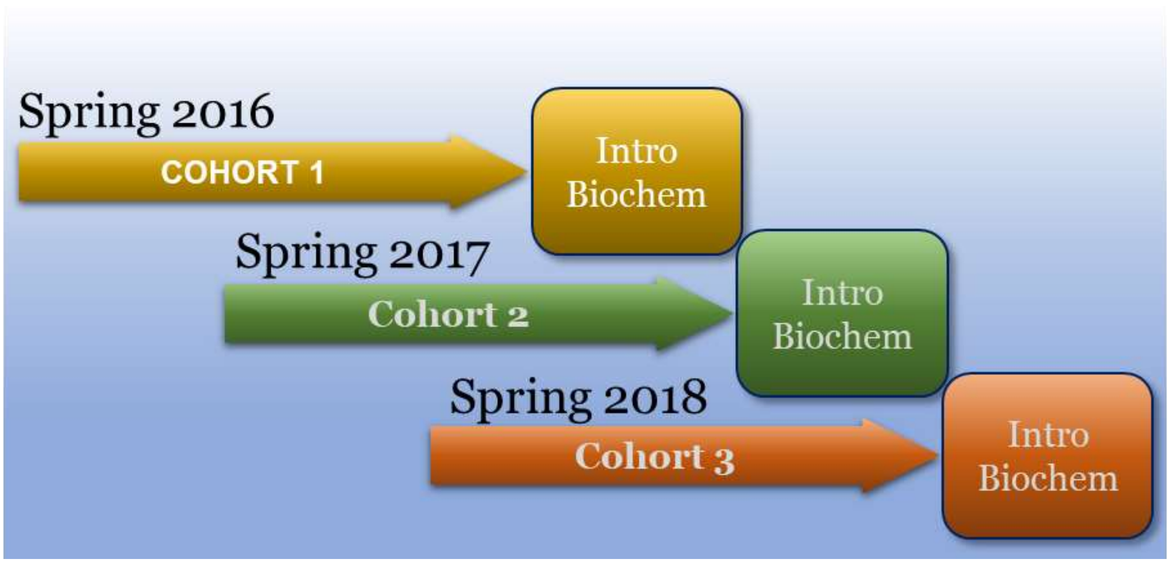


Figure 2.1. The study described in this chapter spans several years. Cohort 1 began General Chemistry 2 in Spring 2016. The final set of data from Cohort 3 was collected in Spring 2020 because students commonly enroll in Introductory Biochemistry in the Fall or Spring semester after they complete Organic Chemistry 2.

Table 2.1. Classes Involved

Course	Typical Size of Experimental Class	Typical Size of Control Class	Intervention
General Chemistry 2	330	300	Pharmacogenomic Poster Project
Organic Chemistry 1	110	250	Nutrigenomic Role-Play Journal
Organic Chemistry 2	70	300	Nutrigenomic Role-Play Journal

General Chemistry II: Introduction to the Chemistry Principles of Pharmacogenomics:

The multi-semester intervention begins in G2 with a semester-long research project in which students connect abstract general chemistry principles within the context of pharmacogenetics, the intersection between pharmaceuticals and genetics. For example, a single nucleotide polymorphisms (SNP) is a single-point mutation of DNA in which a single nucleobase, such as adenine, is replaced with another nucleobase, perhaps guanine. The results of this SNP could have incredibly far-reaching consequences if, for example, if the 226,019,633rd nucleobase on chromosome 1 is a cytosine instead of a thymine. Patients with epilepsy and a C_C genotype may require an increased dose of carbamazepine, an anticonvulsant, than patients with a T_T genotype.[17]

Project-based research assignments are commonly used in K12 classrooms and higher education.[18,19] Group research and collaborative project-based learning is also used in college chemistry courses.[20–23] The effects of personal genome testing on medical and graduate student learning has also been previously investigated.[24,25] The significance of the group research project assigned in the experimental sections of G2 was that this research project would be personally meaningful to general chemistry students because they were learning to interpret their own personal genome. Participants in this study were offered a 23andMe direct-to-consumer personal genotyping kit. This study was approved by the Institutional Review Board of University of Illinois at Urbana-Champaign. Students were not required to accept a 23andMe kit, nor were students ever required to submit any of their personal genomic data at any point in this study. In fact, instructors were never informed who did or did not participate in the study or receive a 23andMe kit. The purpose of offering students a 23andMe kit was to make chemistry personally meaningful by draw attention to the abstract chemistry principles operating in each students' personal genome.

For this project, student groups conduct research on the chemical mechanism of their assigned drug and must propose a chemical explanation for why their assigned mutant protein might interact favorably or unfavorably with their assigned drug. In the case of the rs1051740, the SNP in EPHX, the tyrosine that is normally expressed is instead replaced with a histidine residue. A clever student may then recognize that tyrosine does not have an acidic side chain whereas the histidine side chain has a pKa of approximately 13.1. This student may then propose that the increased acidity alters the mechanism of EPHX1 in some way. This final proposed mechanism is often outside of the scope of their chemistry knowledge, but it serves to connect their newly learned chemistry principles, such as acidity, thermodynamics, kinetics, redox, intermolecular forces, etc., with the molecular etiology of interindividual drug efficacy.

The logistics of this part of the multi-semester intervention are considerably demanding. Every student in the G2 course (~320 students) was required to work in a group of 4 or 5 (~80 groups total). The project was divided into seven assignments each due approximately two weeks apart. Each student had to complete rough drafts for each of the seven assignments on their own, and then work with their groups to submit a final draft for each assignment. Student groups compiled their assignments into a single poster and submitted their group poster for printing at the university document services.

In the first assignments, students are prompted to install GenomeBrowse, a free genome viewing program, onto their laptops or visit the computing lab which had GenomeBrowse installed on all the computers. Students used GenomeBrowse to find the gene that contained their SNP, as shown in Figure 2.2. They also conducted a search on PharmGKB, a pharmacogenomic database with information on known drug-gene mutations interactions, to investigate known inter-individual response differences to their assigned drug.

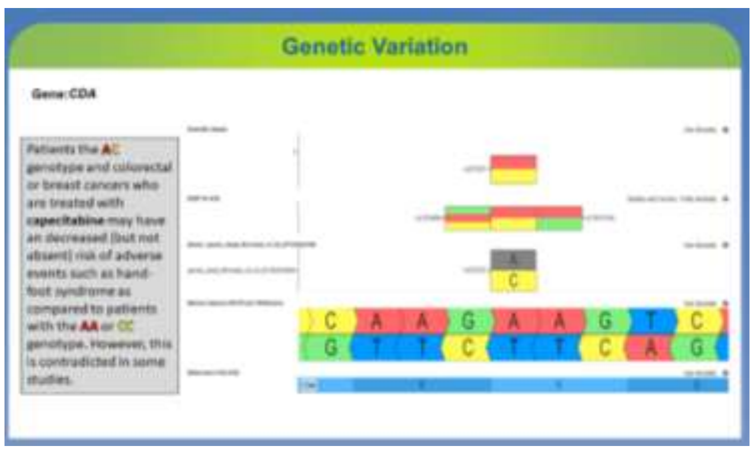
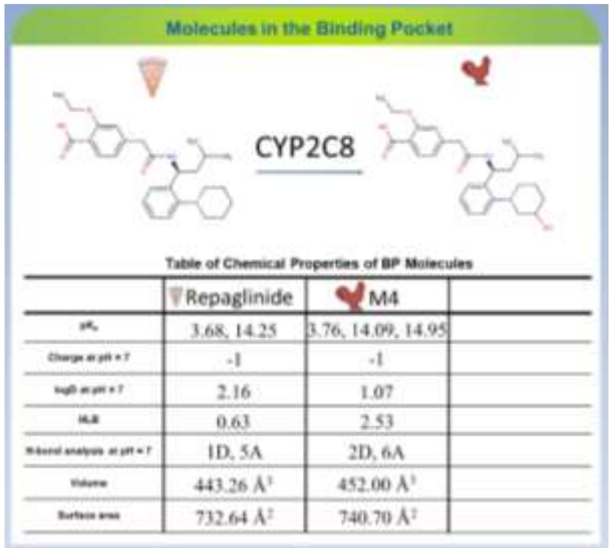


Figure 2.2. GenomeBrowse provides students with a visualization of the location of their SNP in its corresponding gene and also with its position in the human genome.

For the second assignment, students used MarvinSketch, a free chemical drawing program, to draw and investigate the chemical properties of their assigned drug and its relevant metabolites, as shown in Figure 2.3. With the PharmGKB database, students were able to search for known metabolites of their assigned drugs. For example, CYP2C8 oxidizes repaglinide to add an alcohol group and form the M4 metabolite with slightly different chemical properties. Although the mechanism of this reaction is out of the scope of G2 students, the new alcohol groups on the metabolite present the G2 student with an opportunity to investigate how these alcohol groups affect the chemical properties of this metabolite. This assignment was concurrent with the acid/base portion of G2 so students were able to discuss the pKa's of the new alcohol groups. Each student group was assigned a different drug, so there were many different metabolites being discussed inside and outside of class.



	Repaglinide	M4	
pK_a	3.68, 14.25	3.76, 14.09, 14.95	
Charge at pH = 7	-1	-1	
logD at pH = 7	2.16	1.07	
HLB	0.63	2.53	
H-bond analysis at pH = 7	1D, 5A	2D, 6A	
Volume	443.26 Å^3	452.00 Å^3	
Surface area	732.64 Å^2	740.70 Å^2	

Figure 2.3. Students use MarvinSketch to draw their assigned drug and its relevant metaoblites. MarvinSketch is capable of providing students with simple chemical properties of their molecules.

Assignment three was very similar to the second assignment, in that students had to use MarvinSketch to investigate the chemical structure and properties of specific molecules. However, in this case students compared the chemical properties of the wild-type and mutant amino acids related to their assigned SNP, as seen in Figure 2.4. At this point in the semester students have discussed partition coefficients and are able to understand the hydrophilic-lipophilic balance (HLB) of their drugs and its relevance to their assigned drug. MarvinSketch is can be used to conduct the calculations shown here with the appropriate license granted from its publisher, ChemAxon.

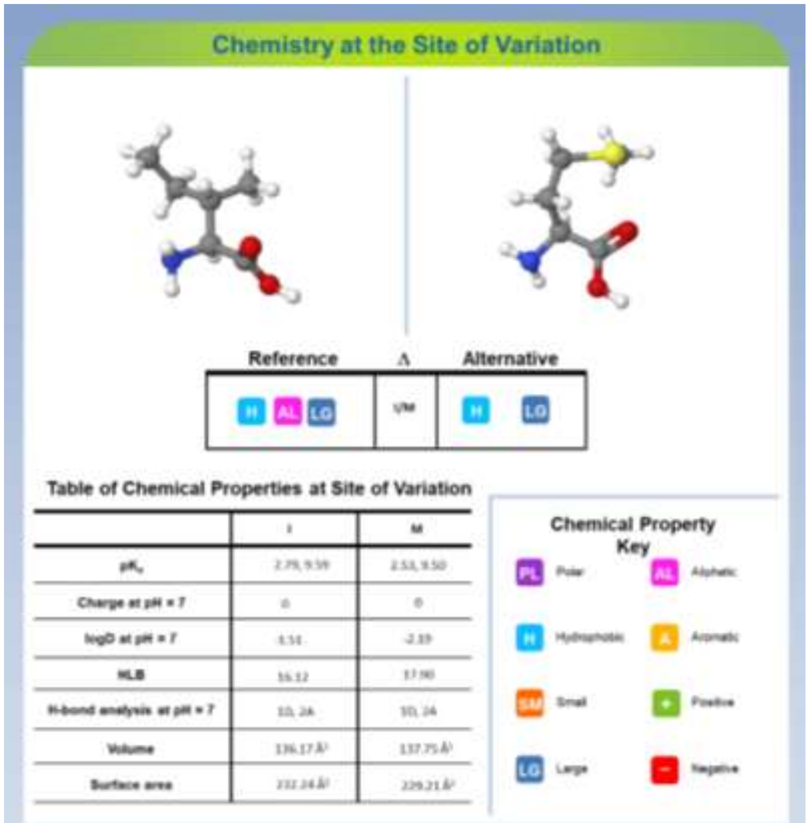


Figure 2.4. Students compared the chemical and structural properties of wild-type and mutant amino acids related to their assigned SNP. In this sample, Isoleucine and Methionine are being compared. G2 students reasoned that the chemical and structural differences of these amino acids were at the root of inter-individual drug response to carbamazepine.

Next, students searched searched the Mutation Position Imaging Toolbox (MuPIT) website for a 3D model of their protein product. Figure 2.5 shows a visualization of Epoxide Hydrolase 1 with the mutation position clearly shown. This allowed students to discuss whether their SNP affected the active site of their protein product or perhaps caused a detrimental conformational change.

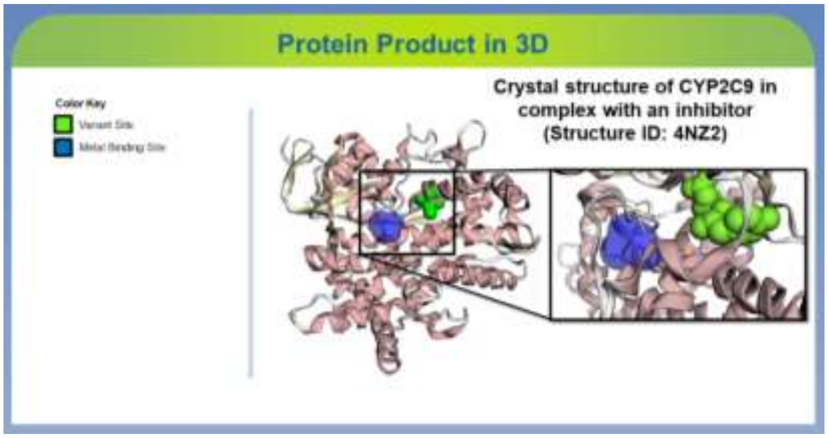


Figure 2.5. MuPIT was used to collect a visualization of the mutation on the student's protein product, in this case, the variant site is near the metal binding site of CYP2C9. A student may reason that replacing an amino acid at this position with a significantly different amino acid would clearly have repercussions for CYP2C9 effectively oxidizing its substrates.

The fifth assignment prompted students to make sense of all their research by putting together a small, simple cartoon of their drug interacting in patients with different genotypes. While this cartoon is quite simple, this was perhaps the most challenging portion of the research project. To facilitate this assignment, students were provided with a simple legend from which they could pull key elements for their cartoon, as shown in Figure 2.6. After putting together a simple cartoon depiction of the inter-individual difference in drug response between patients with a native or mutant amino acid, students were prompted to decide if the mutation affected the pharmacokinetics or pharmacodynamics of their assigned drug. Students were not expected to develop an expert-level understanding of pharmacokinetics and pharmacodynamics. They were given a brief introduction into these concepts along with their lecture on kinetics and thermodynamics.

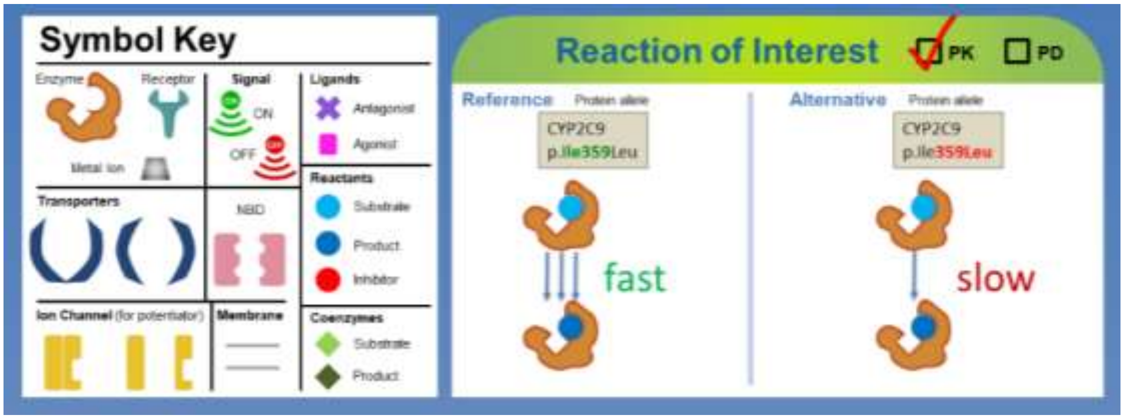


Figure 2.6. The Reaction of Interest assignment connected kinetics and thermodynamics with pharmacokinetics and pharmacodynamics of drugs. In this example, the student is illustrating that the mutated CYP2C9 is much slower at oxidizing its substrates.

Assignment six prompted students to revise all of their previous assignments and make adjustments to their entire poster. Assignment seven prompted students to submit their posters for printing, paid for with grant funds at no cost to the students, and prepare ‘elevator speeches’ to present their posters, a sample of which can be seen in Figure 2.7.

Each group presented their poster during the last week of instruction. A large atrium was reserved for two days to host this poster session. On the first day of the poster session, even numbered groups presented their work while odd numbered groups attended the poster session to ask questions and vice versa on the second day. Students were encouraged to invite their friends from other classes to view the fruits of their labor. Additionally, chemistry professors from other classes also attended to ask student presenters questions about their work.

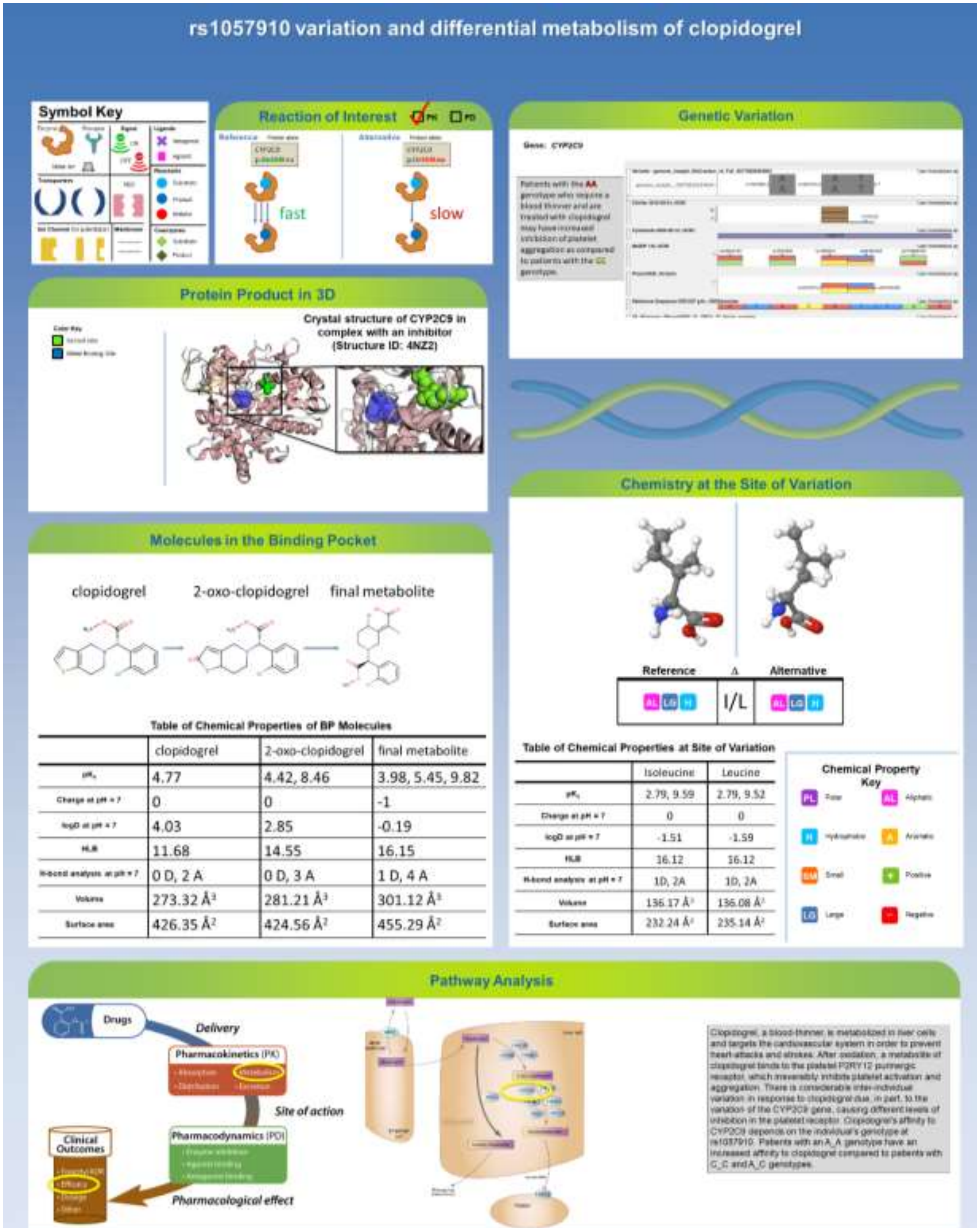


Figure 2.7. This is a sample of a student poster that was created for the G2 intervention. Student groups were provided with a template to fill out.

Each of the seven group assignments required students to individually complete a homework assignment before working on their group assignment. The seven individual assignments were worth 3.5% of each students' grade, the seven group assignments were worth another 3.5% of each students' grade, and the poster presentation was worth 4% of each students' grade. Ultimately, students earned 10% of their final G2 grade for their individual and group work throughout the semester. Individual assignments were delivered via the online homework platform and graded for accurateness. The group assignments and final poster presentation were graded for accurateness, reasonable arguments, and presentation skills. The group work was manually graded with the assistance of several undergraduate TA's. Students received a grade based on the successful completion of their individual work and based on the quality of their group's poster and presentation.

Organic Chemistry 1 and 2: Introduction to the Chemistry Principles of Nutrigenomics:

In Organic Chemistry 1 and 2, students had to complete role-play exercises in which they assumed the role of a physician explaining the chemistry principles behind an illness or dietary suggestion to a hypothetical patient. This prompt was intended to make the journal assignments personally meaningful to students by connecting abstract chemistry with their personal career aspirations. Unlike G2, most students in O1 are pre-health majors seeking to become physicians. It was therefore expected that this stage of the multi-semester intervention would have a strong effect on many of the students because very few engineering and non-health majors take O1. And, of course, to make these nutrigenomic journals more personal, students were taught how to connect their 23andMe information to the GBHealthwatch website so that they could learn about their own nutrigenomics if they were so inclined.

Students had to write and draw their thoughts into an artistic journal entry which would be submitted for credit. The pedagogical value of this exercise is in tasking students to communicate chemistry principles in layman terms to summarize and internalize abstract chemistry. The expected motivational value of these exercises was to make students aware of the utility value of learning chemistry principles well enough to explain them to a patient. It was important that students created artistic journals because the process of creating summative art is inherently slow and requires that the student express a little bit of themselves through the journal medium. The slow process of creating art with hand-drawn or clipped images, allows students to think metacognitively assign meaning to the new abstract concepts they learned in class and construct new knowledge.[26] Journaling in the classroom is by no means a novel concept, many instructors commonly use reflective journal prompts as an instructional practice.[27] However, it is yet more impactful when students know they are contributing to a collection of journals that can be presented to future classes and that they can keep at the end of the semester instead of throwing away.[28]

Students were assigned four role-play exercises spread out through the semester. These role-play exercises were worth 10% of the overall course grade. An example of one journal entry is shown in Figure 2.8. The journal prompts typically related to something they had recently learned in class. For example, after learning about saturated and unsaturated fats, students were visited by their hypothetical patient, Emma, who was concerned about ‘good’ and ‘bad’ fats in her diet. According to the journal prompt, Emma had heard various rumors and misinformation about fats. Students had to clearly explain to her the structural and functional differences between fats, lightly discuss their nutritional value and give her some dietary suggestions that she could begin to implement in her own diet. In another journal prompt, titled Syrup

Sandwiches Inside My DNA, students read a brief article on the genetic mutations that may affect the amount of satisfaction people experience from eating food. In this journal, students had to explain that food satisfaction is not directly a property of the chemicals in food, it also depends on the neurological response to those chemicals. A sample prompt can be seen below along with some snapshots from various student journal entries that demonstrate a typical student response to the assignment. This sample journal prompt would be assigned at the end of the semester when students had completed other journals with more specific directions. In this case, students were tasked with using an online cardiovascular risk calculator to diagnose their hypothetical patient's risk for heart disease in the next 10 years.

Syrup Sandwiches Inside My DNA: After missing several appointments during the past few months, Billy Ashcraft has returned to your office today concerned about his heart health. Diagnose Billy's cardiovascular risk, suggest a healthier diet based on a previously covered topic, and explain a relevant chemistry principle behind your decision. Remember to use empathetic language to increase the chances that Billy will follow your suggestion!

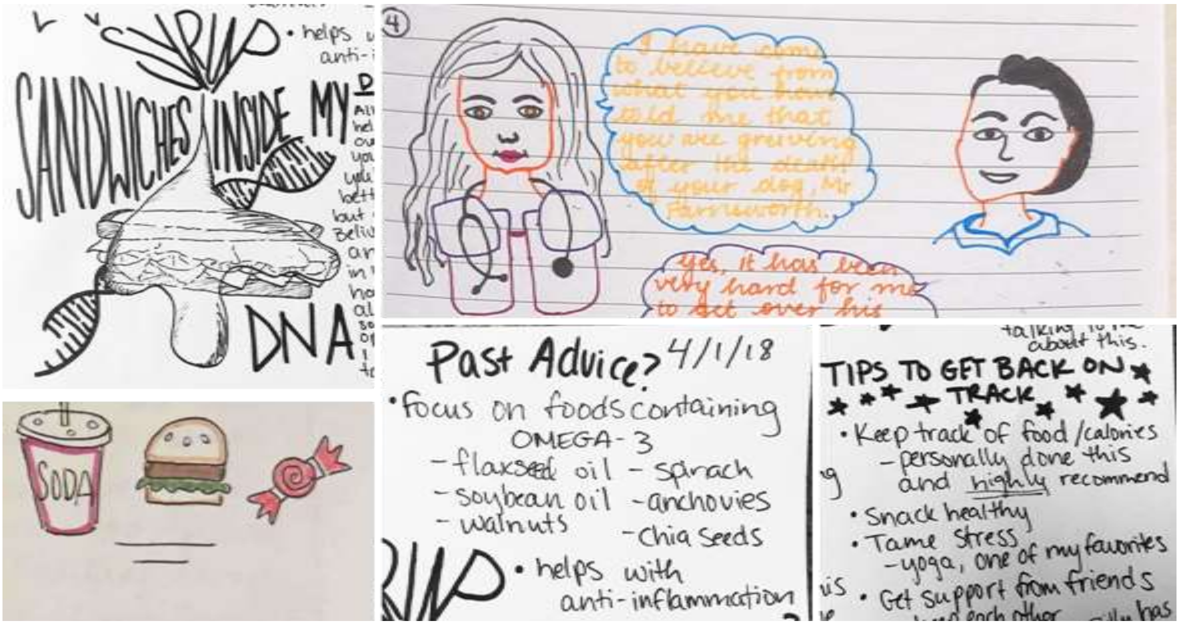


Figure 2.8. Snapshots from several different students' journal entries are combined here to summarize the key components of the O1 and O2 intervention. Typically, students were given a scenario where a hypothetical patient came into their physician's office with an inquiry about the chemical principles of a disease or health condition. Students were required to respond empathetically and in common layman terms to explain relevant chemistry principles recently covered in class.

Results:

We present two approaches to evaluating the learning differences between experimental and control sections. These include analysis of final grades in introductory biochemistry and focus groups consisting of experimental students that have completed introductory biochemistry. At the time of writing this chapter, the study is in its late stages and the analyses and data collection have not yet been completed for all three Cohorts. Here, we present the analysis of introductory biochemistry course grades for Cohort 1 and 2, and the focus group data for Cohorts 1 and 2.

Organic Chemistry II Curiosity and Interest Results:

Curiosity and Interest were measured using the 10-item Epistemic Curiosity Scale.[12] Participants responded to an online survey and responded to each of the 10 questions by rating themselves on the following 4-point frequency scale: 1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Almost Always. The 10 questions are divided into two categories for scoring to reflect whether they measured D-type curiosity or I-type curiosity, which may also be described as curiosity or interest.[29] These 10 questions are shown in Table 2.2 below.

Table 2.2. Epistemic Curiosity Scale Questions

Curiosity (D-type)	Interest (I-type)
I can spend hours on a problem because I just can't rest without knowing the answer.	I enjoy exploring new ideas.
Difficult conceptual problems can keep me awake all night thinking about solutions.	I enjoy learning about subjects that are unfamiliar to me.
I enjoy discussing abstract concepts.	I find it fascinating to learn new information.
I work like a fiend at problems that I feel must be solved.	When I learn something new, I would like to find out more about it.
I brood for a long time in an attempt to solve some fundamental problem.	I enjoy discussing abstract concepts.

Based on these data from General Chemistry 2, Cohort 2, shown in Figure 2.9, there is no difference in curiosity or interest between the intervention or control sections at any time point during the semester. This may be interpreted as suggesting that the PGX intervention was not successful in promoting curiosity and interest in this sample of students. It could also be interpreted as suggesting that any increases or decreases in curiosity and interest within subpopulations of the class were not noticed as a result of averaging the curiosity and interest scores of the entire class. Based on the focus group data, a third interpretation could be that the PGX intervention was difficult to understand for many students resulting in no difference in curiosity and interest for many students.

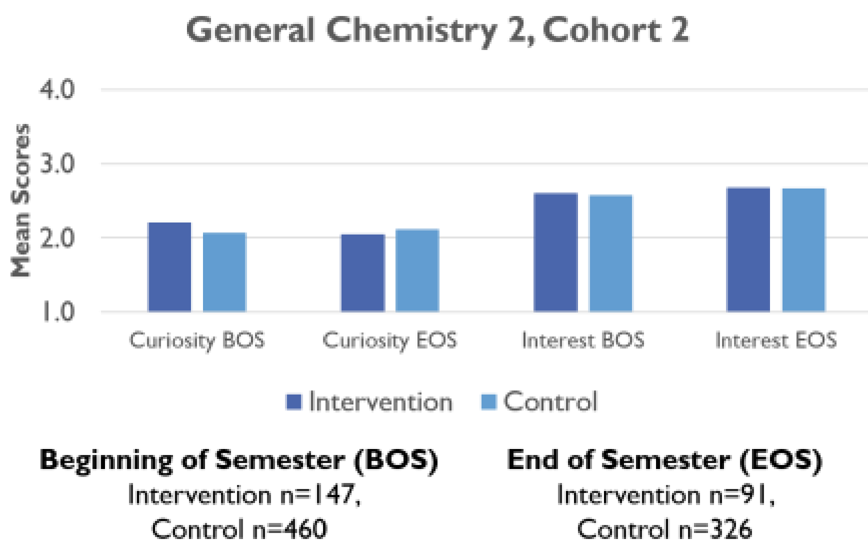


Figure 2.9. This graph shows no difference in curiosity or interest between the intervention and control groups at the beginning or end of the semester. Possible interpretations of this data are (1) that averaging the curiosity and interest of the entire class of students misses any potential changes in curiosity and interest within subpopulations of students or (2) the PGX intervention had insufficient traction with students as a result of its difficulty.

Based on the data from Organic Chemistry 1, Cohort 2, shown in Figure 2.10, there was a difference in both the average curiosity and interest scores between the intervention and control sections at the beginning and the end of the semester. However, there were no differences between the end and the beginning of the semester curiosity and interest scores in a either the intervention or the control section. Therefore, the differences in curiosity and interest between the intervention and control sections were pre-existing prior to these students enrolling in Organic Chemistry 1. These data suggest that the intervention did not directly influence the curiosity or interest in the intervention section students. However, since students are allowed to enroll in either the intervention or the control section, and they knew the intervention section had a nutrigenomic project, it is possible that the subpopulation of students that enjoyed the PGX intervention in General Chemistry 2 intentionally selected to enroll in the Organic Chemistry 1 intervention section. More data is needed to confirm or refute this interpretation.

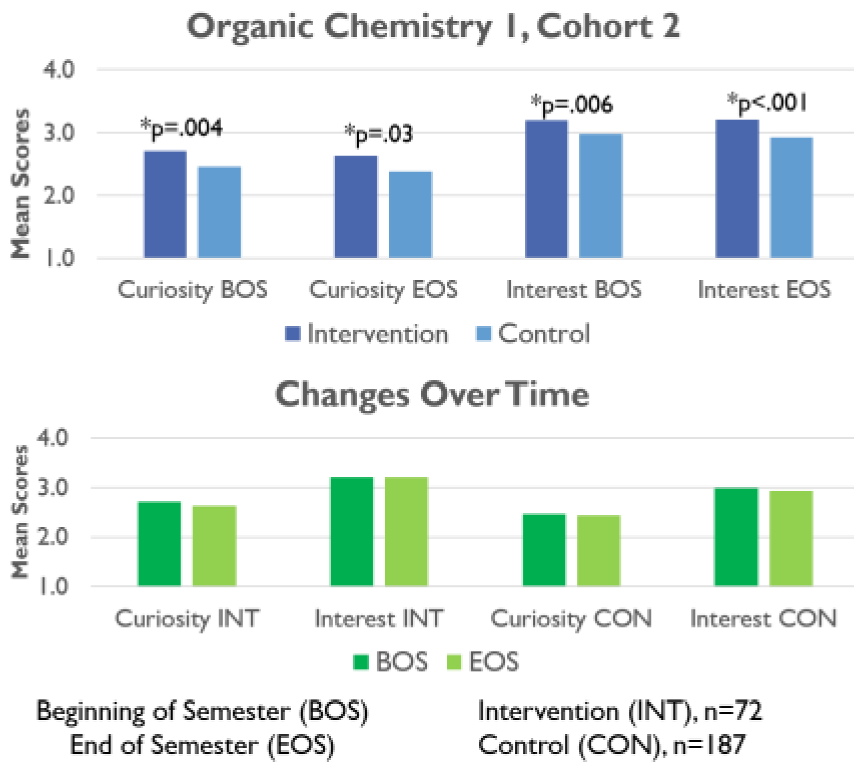


Figure 2.10. The differences in curiosity and interest between the intervention and control sections is not a direct result of the NGX intervention in Organic Chemistry 1, but it is possible that students who most enjoyed the PGX intervention in General Chemistry 2 enrolled in the intervention section of Organic Chemistry 1 because they knew it contained an NGX project.

The data below in Figure 2.11 shows that there are no differences in curiosity and interest between the intervention and control sections of Organic Chemistry 2, Cohort 2. This may be a result of the small sample sizes, but it may also be possible that the NGX intervention in Organic Chemistry 2 had no effect on student attitudes.

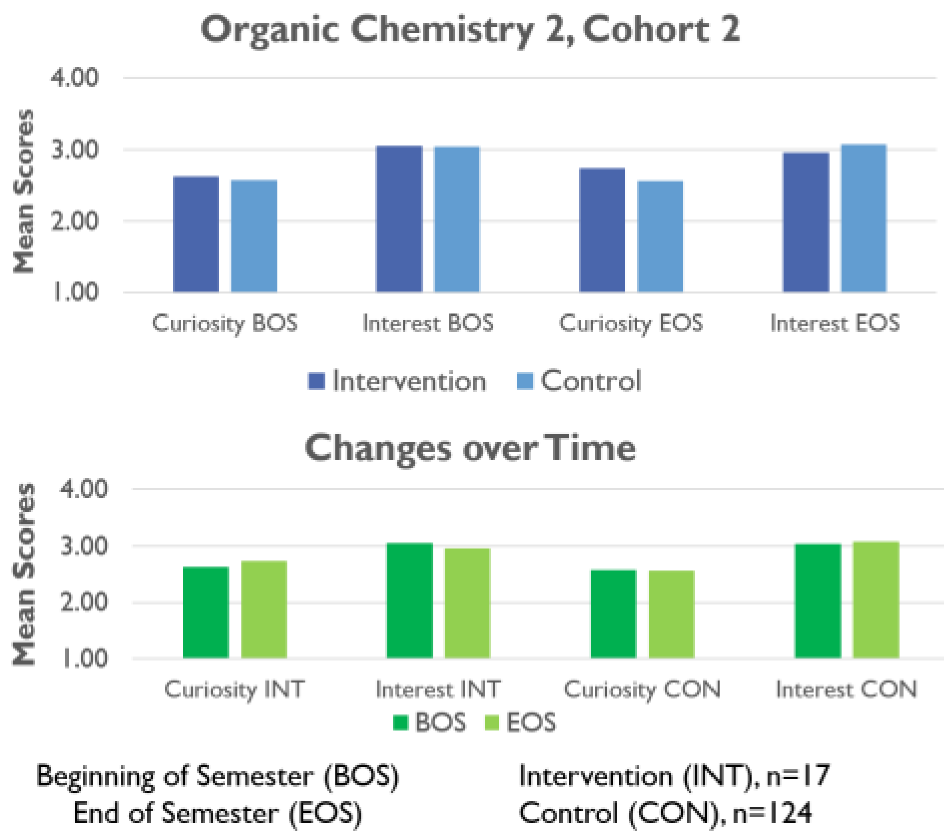


Figure 2.11. There were no differences in curiosity or interest between the intervention and control sections. It is possible that this is a result of small sample size or that the NGX intervention in Organic Chemistry 2 had no effect on student attitudes.

According to Eccles' Expectancy Value model,[2] academic and achievement-related decisions are rooted in a student's expectancy to succeed at a given task and the student's perceived value of succeeding at that task, as shown in the simplified Expectancy-Value model in Figure 2.12. In theory, the Expectancy-Value Model also weighs a students' perceived cost of attempting a task or action, but that is less frequently studied and has been left out of the simplified model shown below.

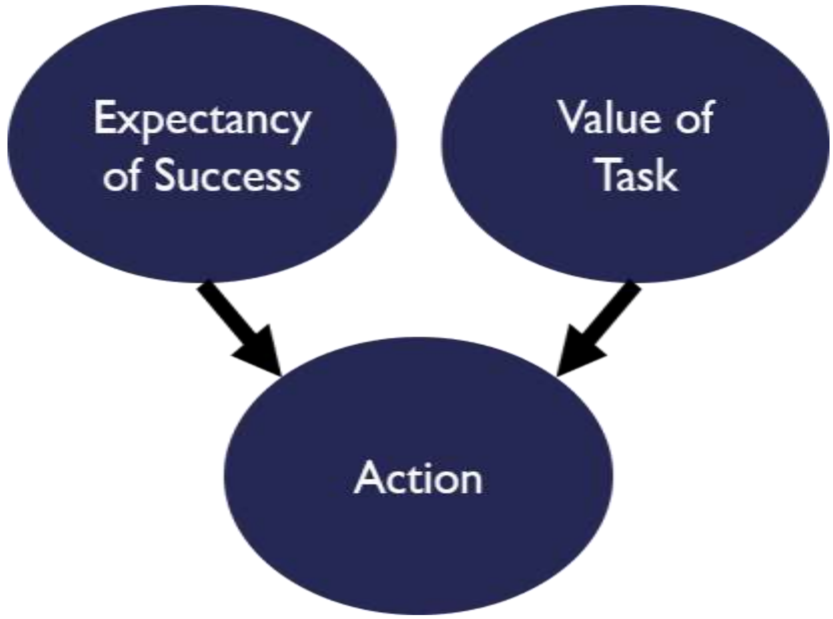


Figure 2.12. The Expectancy-Value Model of motivation balances a students' expectancy of success in an action, a students' perceived value of that task or action, and the students' perceived cost of committing that task or action (not shown here).

For example, a pre-medical student that has high expectations of success in chemistry may choose to pursue a Chemistry minor in addition to their Molecular and Cellular Biology major. This same pre-medical student with high perceived task value in succeeding at chemistry may decide to take the course Drug Development and Discovery at UIUC as part of their chemistry minor to support their future career as a medical practitioner. Students' task value has been found to have a positive correlation with academic achievement in introductory college chemistry (zero-order correlations = 0.21 – 0.30, $p < 0.001$).[3] Task value can be broken down into three subfactors, attainment value, utility value, and interest value.[30] Attainment value refers to the perceived value that a task has for the student's identity. For example, a student that perceives themselves as a physician-to-be may believe that knowledge of the FDA drug approval process is something that a good medical practitioner should have. Utility value refers to a student's perceived usefulness of a task to their future career. For example, a student may believe that a strong grasp of drug design will be advantageous to succeeding in medical school. Interest value is a student's perception of the inherent pleasure of accomplishing a task. For example, a student may believe that drug discovery and design is incredibly fascinating regardless of its potential to benefit them in their future career. Previous intervention studies have found that utility value (UV) interventions are capable of increasing retention and achievement of students in algebra, introductory psychology, introductory biology courses, engineering courses, introductory physics, and introductory chemistry courses.[4–6,31–34] If instructors present chemistry course content in a personally meaningful way, it may be possible to increase retention of low performers in chemistry and increase achievement of low performers in chemistry.

For Cohort 3, the Epistemic Curiosity Scale was replaced with the Four-Phase Model for Interest Development in Chemistry (FPIDC) Scale and three Utility Value questions (see appendix). The reason for this change is because the Epistemic Curiosity Scale does not contain subject-specific questions. It is important for questionnaires measuring curiosity and interest to have subject-specific questions because curiosity and interest are subject-specific emotions. For example, a student may be greatly interested in molecular biology but have little interest in chemistry. For the detailed summary of FPIDC results see the FPDIC and Utility Value ANCOVA Summary in the appendix.

Effect size signifies whether an observed statistically significant difference is large enough to be meaningful. Effect size is represented as Cohen's f for statistically significant results. Effect sizes are considered small, 0.1 to 0.25, medium, 0.25 to 0.4, and large, 0.4 or greater.

The observed difference in end of semester utility value scores for General Chemistry 2, Cohort 3 is statistically significant ($p=0.001$, Cohen's $f = 0.23$). The observed difference in end of semester utility value scores for Organic Chemistry 1, Cohort 3 is statistically significant ($p=0.01$, Cohen's $f = 0.14$). The observed difference in end of semester utility value scores for Organic Chemistry 2, Cohort 3 is not statistically significant ($p=0.09$).

The observed difference in end of semester interest questionnaire scores for General Chemistry 2, Cohort 3 was statistically significant ($p<0.001$, Cohen's $f = 0.28$). The observed difference in end of semester interest questionnaire scores for Organic Chemistry 1, Cohort 3 is not statistically significant ($p=0.11$). The observed difference in end of semester interest questionnaire scores for Organic Chemistry 2, Cohort 3 is not statistically significant ($p=0.76$).

Of these findings, perhaps the most intriguing results from the FPIDC questionnaire is that the General Chemistry 2, Cohort 3 PGX intervention resulted in a small positive effect on utility value of chemistry and moderate positive effect on interest in chemistry. These results contradict the earlier findings from the Epistemic Curiosity Scale results of General Chemistry 2, Cohort 2 which suggest that the PGX intervention had no effect on student curiosity and interest. One interpretation of these results is that the PGX intervention applied in Cohort 3 was more successful than the one applied in Cohorts 1 and 2. Indeed, the PGX intervention applied to Cohort 3 was thoroughly revised in Fall 2017 to include clearer instructions and to focus on making stronger, better timed connections between the PGX project and the General Chemistry 2 content. These results, therefore, support the notion that implementing new instructional methods in the classroom requires several iterations and revisions to be successful. Any educators seeking to innovate in their classroom should keep this in mind – the first time through the brick wall hurts the most, but the view may be worth the pain!

Introductory Biochemistry Comparison:

After students have completed O2, they often take introductory biochemistry, either MCB 354 or MCB 450 depending on the student's major. The number of students that take MCB 450 are too few to conduct a meaningful analysis, therefore only the analysis of participants that took MCB 354 are presented here. No intervention is applied in MCB 354, so students that were previously separated into intervention and control sections of G2, O1, and O2 are all gathered into the same sections of MCB 354. They complete the same assignments and take the same exams. Therefore, the academic performance of intervention and control participants is compared based on the averages of their final course grades in MCB 354. The introductory biochemistry class is graded on a 1000 point scale.

When comparing the MCB 354 average performance between students that took either the intervention or control sections of G2, O1, and O2 with no crossover, students switching between the experimental and control sections, no significant difference was found. However, a comparison between students of the intervention (n = 59) and control (n = 90) sections of O1 and O2 found a significant difference (p=0.04) with a small effect size.

An Analysis of Covariance (ANCOVA) was performed to investigate if the difference between the mean scores of students in the experimental sections and students in the traditional sections could be attributed to the multi-semester intervention or preexisting academic ability. Both ACT Composite and ACT Math scores were used as controls in the ANCOVA and produced similar results. When controlling for the ACT Composite score, students who participated in the intervention O1 and O2 courses scored **33.79 points higher** than the control with an effect size Cohen's f = 0.17. When controlling for the ACT Math score, students who participated in the intervention O1 and O2 courses scored on average **34.07 points higher** than the control with effect size Cohen’s $f = 0.18$. One letter grade on the MCB 354 grading scale is approximately 120 points, so this suggests that participating in at least the O1 and O2 intervention sections helped students perform roughly a quarter of a letter grade better in MCB 354.

There may be no difference in MCB 354 performance between students of the intervention and control G2, O1, and O2 courses because of the difficulty in making meaningful connections with the G2 intervention. Due to the difficulty of the pharmacogenomics poster project in G2, students had widely mixed opinions on the poster project. Opinions of the project that were favorable typically came from students that were pursuing careers in healthcare, enjoyed the challenge of doing research on a subject with unanswered questions, and/or enjoyed group work. Opinions that were unfavorable typically came from students that were pursuing careers in engineering or other non-health careers, students that disliked researching a subject with many unanswered questions, and/or disliked group work. These and other diverging opinions were expected, it was also expected that students might struggle to connect topics like acidity to real-life scenarios like genetic mutations and pharmaceuticals. What was not expected, however, was the vast disparity of technology ability among a class of 300 G2 students. The G2 intervention relied on moderate technological ability, and although careful attention was paid to helping students surpass technological difficulties so that they could focus on the connections between pharmacogenomics and general chemistry principles, many students still struggled to find necessary files on their laptops or install software. This may help to explain why there is no significant difference in the MCB 354 performance of participants between the intervention and control sections of G2, O1, O2.

Unlike the G2 intervention, the O1 and O2 interventions did not require any more technological ability than that which is required to check the syllabus online or upload photographs of assignments to the online discussion platform. Since the O1 and O2 interventions only required that students role-play as a physicians and that they attempt to create an artistic journal entry detailing their role-play exercise, there was a much smaller barrier to making connections between nutrigenomics and organic chemistry principles.

Focus Group Highlights and Discussion:

Focus groups were conducted during the spring semester immediately following introductory biochemistry. The focus groups were attended by 8-10 intervention students in the second semester of their junior year. The focus group was scheduled for two hours in the evening and refreshments were offered to entice participant attendance. In general, participants were asked if their experiences in the multi-semester intervention benefitted or harmed their learning of chemistry and their performance in introductory biochemistry.

Based on the focus groups, we have learned that intervention section students feel that they are more confident and competent in biochemistry than their control section colleagues. Participants largely attributed their confidence in biochemistry to the great level of detail they learned in their intervention organic chemistry courses. The focus group also highlighted the following recurring themes (1) a deeper understanding of pathways (2) increased confidence when reading research articles and studying for the MCAT (3) sense of community despite being in a large university (4) chemistry seemed much less abstract and much more real life. However, it should be noted that the participants did not feel that they needed the intervention to succeed in biochemistry. In fact, the participants strongly agreed that they would have performed well in biochemistry if they had been in the control section. Specifically, one participant stated, “If I had gone through the control sections, I could have done well [in Biochemistry] but I would have felt like, ‘Yeah, I survived it’. But going through the experimental sections I felt like, ‘Yeah, I kind of enjoyed that actually.’” It should be noted that this was stated by one of the students who confessed to having struggled a great deal with chemistry. This student reported that the O1 and O2 interventions helped them make personal connections with chemistry that they otherwise would not have made. The participants agreed that one of the major differences between the intervention and control sections was that they learned to enjoyed biochemistry more than they would have without the O1 and O2 interventions.

Participants strongly agreed that the poster project in G2 felt out of place with the content they were covering in G2. They also agreed that the scope and complexity of the poster project discouraged a number of their classmates from continuing in the intervention sections of O1 and O2. Additionally, the participants suggested that the G2 intervention would be more approachable, enjoyable, and impactful if it was included in O1 rather than G2.

Participants that had completed their MCAT exams before attending the focus group mentioned that they felt more confident preparing for the MCAT because of their experiences in the intervention sections of this study. Some of the students that were in research groups on campus also mentioned that the G2, O1, and O2 interventions did not have an effect on whether they joined a research group or not, but they did have a positive effect on the interest and pleasure derived from their research.

Limitations of the Study:

Running this study over several years with three cohorts brings the number of General Chemistry 2 participants above 1000 students in total. However, the number of participants that continue with this study through introductory biochemistry dwindles down to fewer than 200 students in total. This sample size limits the assessments possible for this study and limits the implications of the preliminary results presented in this chapter.

In addition to the quantitative limits of the findings, there are also qualitative limits regarding the efficacy of these interventions on students from other universities. This study was performed at a university with a small under represented minority (URM) population; the interventions in this study may or may not be as effective for universities with more URM students. In this study, URM was defined as American Indians or Alaska Natives, who maintain tribal affiliation or community attachment, Blacks or African Americans, Hispanics or Latinos, Native Hawaiians or Other Pacific Islanders, and multi-racial students when one or more are from the preceding racial and ethnic categories in this list. Further, UIUC is an R1 university which brings into question the implications for universities with student populations that have different career goals, academic abilities, and socioeconomic backgrounds.

Perhaps inevitably, there are slight differences in fidelity to the intervention amongst the three cohorts. While the instructors for the experimental and control sections of General Chemistry 2, Organic Chemistry 1, and Organic Chemistry 2 were the same for each of the three cohorts, the experience of each instructor varied to some degree. The instructor for the experimental O1 and O2 courses and the instructor for the control O1 course were young faculty with less teaching experience than the experimental and control G2 and control O2 courses. Over the course of the study, these young instructors improved their made several changes to the presentation of their materials. The intervention itself was implemented and graded by a graduate student with the assistance of several undergraduate TA's. However, the delivery of course content in the experimental classes of O1 and O2, and the control classes O2 may have been slightly adjusted or improved across the three cohorts. Similarly, it is also likely that the control sections presented their classes slightly differently knowing that their students were part of a study or because they connected current events with their regularly scheduled material. For example, if a control section instructor felt pressured knowing their class was part of a study they may have made efforts to alter their teaching practices to engage students beyond their normal practices.

Furthermore, it is out of our capabilities to control for the study habits of students outside of the course. The discussions between experimental and control section students may positively or negatively influenced their study habits and curiosity development when, for example, experimental section students shared their poster projects and journals with control section students, or when control section students shared their traditional material to the experimental section students. Another possibility is that students from different sections shared explanations from their instructor to a student that did not understand their own instructor's explanation. The preliminary findings in this chapter were controlled for ACT Composite and Math scores, but external influences from students' friends, knowledge gained from chemistry-related courses, or elsewhere could not be controlled by the research team.

Conclusion:

In this study, a multi-semester intervention targeting students' curiosity and utility value was implemented in General Chemistry 2, Organic Chemistry 1, and Organic Chemistry 2. Curiosity and interest were measured using Epistemic Curiosity Scale for Cohorts 1 and 2, and a FPIDC questionnaire based on Expectancy-Value theory was used to measure Interest and Utility Value in Cohort 3. The intervention applied to General Chemistry 2, Cohort 3 had a moderate positive effect on interest and a small positive effect on utility value for students. Focus group data has indicated that there are additional motivational benefits from the intervention that are not being measured by the existing metrics presented in this chapter. In addition to the motivational benefits of these interventions, the research team believes there is pedagogical value in the assessment of the intervention components discussed in this chapter.

Overall, role-play exercises and journaling show promising results and should be investigated further. Unlike the pharmacogenomic group research project, the role-play exercises and journal intervention components are incredibly cheap, require little technological ability to implement, and provide a highly flexible medium to connect chemistry principles to students' personal interests. Future work should look more deeply into the effects of role-play journals on motivational variables such as curiosity and interest.

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CHAPTER 3: SLOWING STUDENTS DOWN TO DISCOVER CONNECTIONS

"The Earth without art is just 'Eh'"

– Banksy

Abstract:

The authors of *Slow Professor* have drawn attention to the culture of speed which they claim is growing prevalence throughout academia. This culture of speed has the detrimental tendency of pushing students to prioritize quickly completing course material over slowly and purposefully drawing connections between course materials. Described herein is a method for using journal assignments in two different college organic chemistry classrooms to slow students down to think slowly about organic chemistry and make connections to the macroscale world and other college courses. In one special topics in chemistry classroom, these collage journal assignments replaced conventional methods of assessments, such as quizzes and exams, and required students to conduct their own research to make connections between general chemistry and genetic mutations, such as the differences in acidity between amino acids. In the second case, artistic journal assignments were used as an assessment in addition to quizzes and exams in a sophomore organic chemistry course with the intention of contextualizing laboratory chemistry concepts within the field of healthcare. Student attitudes toward using journal assignments in the classroom were generally positive, as demonstrated herein with samples of student work and snippets of student opinions.

Introduction:

General and organic chemistry courses for non-chemistry majors at University of Illinois Urbana Champaign have class sizes that range between 100 to 500 students. These classes are held in large lecture halls or online and they all use online platforms for homework assignments and quizzes. These online platforms typically offer large pools of questions which make it easy for instructors to select questions to tailor homework assignments for their class. Additionally, online homework platforms also provide automatic grading, real time hints that direct students toward the correct answers, and instant feedback on student performance. Online homework platforms make it very easy for instructors to administer homework assignments and provide feedback for large class sizes nearly instantaneously, but does this emphasis on speed and instant feedback leave enough room for students to thoroughly digest the lecture material?

Online platforms are a great tool for confirming that students are completing their homework assignments and receiving feedback, but they cannot confirm that students are taking the time to thoughtfully reason through their homework and truly consider their feedback. These tools make it possible to look at the performance of individual students or the entire class on specific problems in specific contexts. Based on these metrics alone, many students would appear to be rapidly developing mastery in the course material. However, students may appear to master material online despite showing serious flaws in logic when explaining their reasoning in person. While some online platforms make it possible to ask students to defend their reasoning for questions, these can only be automatically graded if they are in a multiple-choice format. There is no online platform that can automatically grade student short answers – student reasoning must be graded manually. Therefore, despite the speed and simplicity of online platforms, they are not capable of assessing student reasoning. Due to the nature of online grading, it is possible for students to rapidly complete assignments, but online platforms cannot force students to slow down to thoughtfully consider their work in the greater context of the class. It is far too easy for students to shut their laptops as soon as they finish the homework. When students complete the homework problems as fast as possible, they may circumvent the slow, thoughtful process of internalizing the big ideas covered by homework assignments.

Journaling to Slow Down Student Thinking:

Given that it cannot be guaranteed that each student is thinking about their work with an online platform, the authors considered using writing assignments to slow down student thinking. The goal was to slow students down to reflect on their knowledge and consider it in the greater context of the class. Journal keeping and writing assignments in the STEM classroom are relatively rare but are growing in popularity as STEM educators are accepting the pedagogical value of using language to generate knowledge[1–3] and therefore more often choosing to provide students with the learning environment to communicate their scientific knowledge in common terms. For some, it may seem out of place to use a journal assignment in a STEM class. However, writing in organic chemistry courses has been used for over 20 years[4] and is continued to be used in creative ways.[5,6]

A decision was made to use artistic journals because the process of creating summative art is inherently slow and requires that the student express a little bit of themselves through the journal medium. The slow process of creating art with hand-drawn or clipped images, allows students to think metacognitively assign meaning to the new abstract concepts they learned in class and construct new knowledge.[7] For example, if a student discovers that a seemingly insignificant genetic mutation could result in a skin color change with impactful societal ramifications, they may convey that difference in their journal entry with clippings of the genetic mutation adjacent to images of the resulting social injustice.

Students think about new information intellectually and affectively; as instructors, we would be remiss to ignore the emotional connections students are building with course content.[8] For students to develop a real interest in chemistry they must see how chemistry affects their preexisting interests.[9,10] It is important for instructors to share their personal interests in chemistry, but instructors must also encourage students to develop their own emotional connections to chemistry.[11] Journaling allows students to explore the connections between chemistry and their own personal interests.

Encouraging students to build a personal connection to chemistry is a powerful experience and it's even more powerful if done several times in a semester. However, it is yet more impactful when students know they are contributing to a collection of journals that can be presented to future classes and that they can keep at the end of the semester instead of throwing away.[12] In addition to serving as a record of new knowledge, the journals serve as an assessment of what students have learned which is more powerful that assessing them with exams because students tend to cram for exams and dispose their knowledge immediately thereafter.[13]

Journals in a Special Topics in Chemistry Course:

CHEM 199, a Special Topics in Chemistry course worth 1 credit hour, was a companion class to CHEM 104, General Chemistry 2, which is worth 3 credit hours. The aim of CHEM 199 was to train students to use advanced genome-viewing software and artistic journal assignments to understand the molecular etiology of psychological disorders, physiological diseases, social injustice, etc. CHEM 199 was an experiment in methods to help students contextualize abstract chemistry concepts in a personally meaningful way.

In CHEM 199, we prompted students to write weekly journal entries that connected general chemistry with their own individual experiences. We did not have homework assignments or exams in CHEM 199, instead, students submitted a weekly 2-page journal entry summarizing that week's course content and applying or connecting that content to a phenomenon they find personally interesting. Students uploaded a photograph of their journal entries to the Compass2G course website by Friday of every week and received feedback over the weekend.

These weekly journal entries were worth 50% of the course grade, in-class participation was worth 35%, and the final submission of the entire journal was worth 15% of the course grade. Journal prompts, like the one below, typically consisted of open-ended questions that required students to do some informal studying of their own on a subtopic of their choice. These prompts were intended to encourage students to "learn in the wild" about chemistry that they found interesting.[14]

> Discovery in Action: Locate mutations associated with traits and diseases of interest to you. Once you find the locations of these mutations, check your 23andMe data to see what you learn about yourself. Explain the consequences of the mutation.

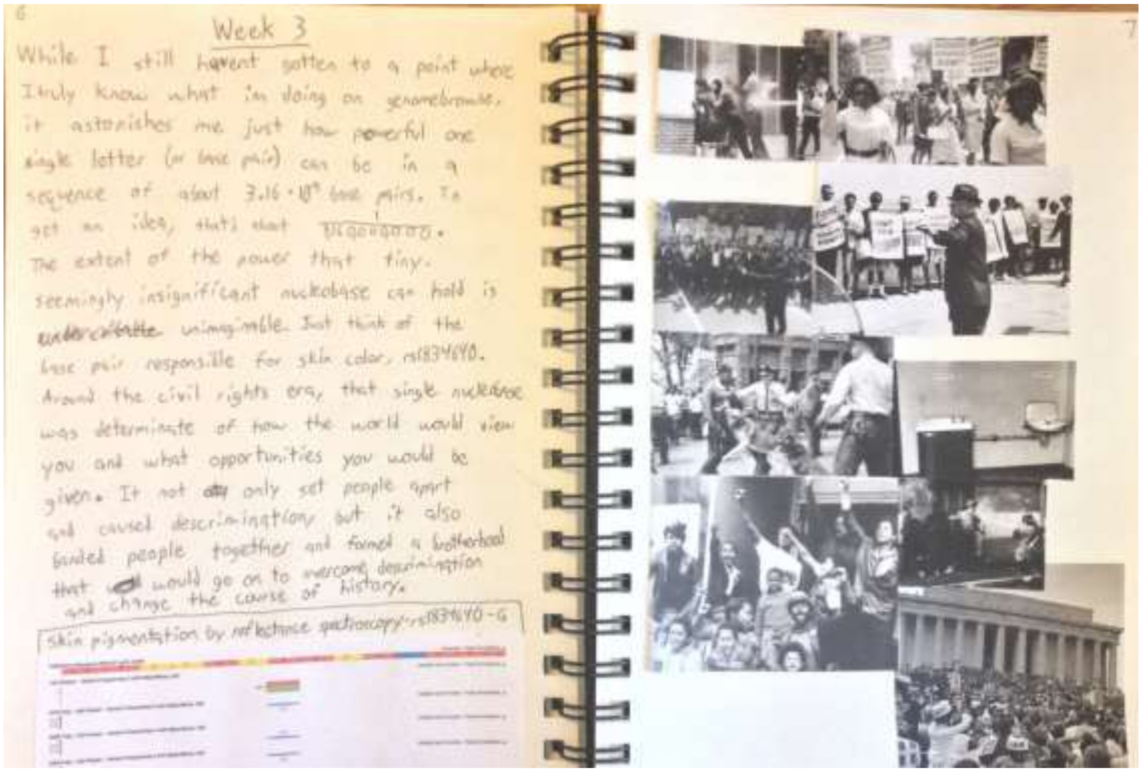

Figure 3.1. In this journal, the student identified a single genetic mutation as a contributing factor to social injustice.

These journal assignments took the place of conventional assessments such as quizzes and exams, as state previously. They were graded using the criteria described in the grading rubric below:

Table 3.1. Journal Assignment Rubric

	Levels of Achievement			
Criteria	**Substandard**	**Basic**	**Proficient**	**Outstanding**
Critical Thinking	**0 points** Rudimentary and superficial; little analysis, synthesis or evaluation; little or no connections with any other material or info is off topic	**11 points** Information is thin and commonplace; somewhat off topic; attempts made at analysis, synthesis, and evaluation; connections are limited; generalities are vague	**13 points** Substantial information; evidence of analysis, synthesis, and evaluation; generalizations are made, but some too obvious or unclear	**15 points** Rich in content; insightful analysis, synthesis, and evaluation; generalizations made; connections made to previous events or previous content
Personal Reflection	**0 points** Lack of connections between personal life, community or past experiences with course content, etc.	**11 points** Little evidence of personal connection; or, connections need further explanation or justification	**13 points** Ideas and thoughts connecting personal life, community, learning, course content, etc.; some gaps in logic or flow of ideas	**15 points** High quality personal reflections connecting real-life, learning, community and/or course content
Surface Features	**0 points** Distracting grammatical or stylistic errors; errors prevent communication	**11 points** Obvious grammatical or stylistic errors; errors interfere with communication	**13 points** Few grammatical or stylistic errors; errors create minimal distraction	**15 points** An occasional grammatical or stylistic error; flaws may even enhance communication by reflecting learning gain or development

The student learning outcomes expected to be accomplished from these journal assignments overlap with the learning goals for next generation science standards outlined in Science.[15] A few of the learning goals outlined therein and covered by this journal assignment include: asking questions and defining problems, looking for and making use of patterns and correlations, demonstrating independence in reading and in writing and speaking about them, and reading, writing, and speaking grounded in evidence. An adaptation of the goals outlined in this article can be seen below:

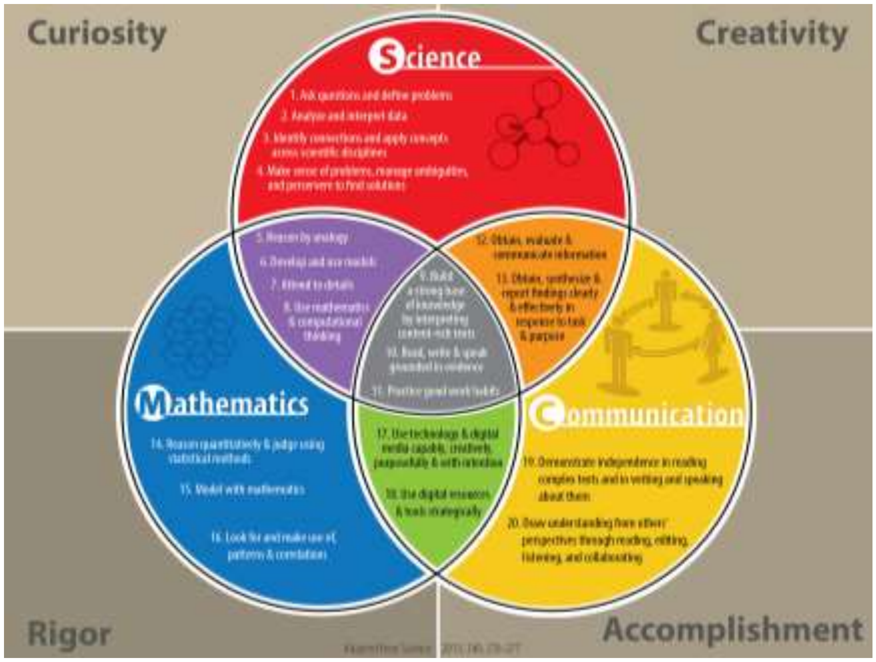

Figure 3.2. The Venn Diagram above is adapted from the article Opportunities and Challenges in Next Generation Standards to outline the overlap with the student learning outcomes covered by the journal assignments used in CHEM 199 and CHEM 232 as described in herein.

Similarly, these student learning outcomes were also covered, and with more depth, in the context of Organic Chemistry 2 for non-chemistry majors, which is offered as CHEM 232 at the University of Illinois Urbana-Champaign. In CHEM 232, these journal assignments were mandatory assessments and were used as a targeted intervention to elicit and harness intrinsic motivation from sophomore non-chemistry majors enrolled in the course. The nature of this intervention is described in Chapter 2: Molecular Sciences Made Personal. The key features of this intervention include using a writing-to-learn style assignment to contextualize abstract organic chemistry principles within a context that is personally and professionally meaningful to the health-related majors that are the major constituents (>90%) of CHEM 232.[16] In CHEM 232, five of these journal assignments were administered each semester to emotionally engage students with the course material. These assignments were each worth 1% of the students' total course grade, for 5% in total. These journal assignments were identical to the CHEM 199 journal assignments described previously in this text. In addition to making a pharmacogenomic or nutrigenomic connection to the organic chemistry context, students were mandated to explain their research findings in layman terms to generate deeper, more meaningful connections with organic chemistry. The act of translating observed natural phenomenon into language, in this case common language, is an act which embodies the learning achieved from observing, reading, or otherwise learning about this natural phenomenon.[2] An example of two such journal assignment prompts and the accompanying student-generated journal entries can be seen below.

> *A Mutation at the Intersection of Genetics, Chemistry, and Human Behavior*
>
> Read this article on dinner & diabetes to get some insight into the connection between melatonin and insulin. In your journal, explain the interaction between melatonin, the MTNR1B receptor, insulin, and blood sugar to a friend or family member. Additionally, describe the consequences of having the rs10830963 risk variant to this friend or family member.

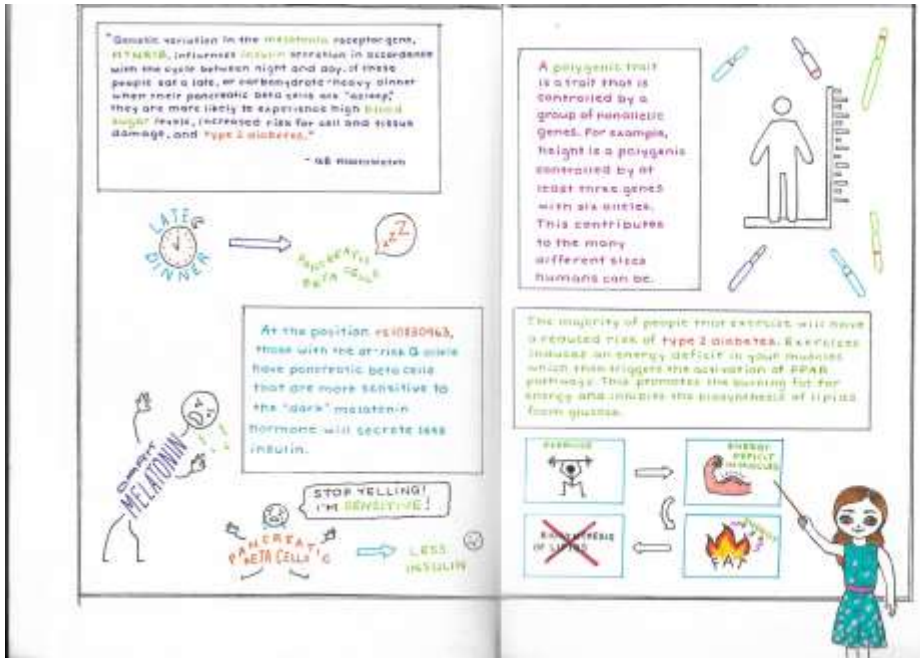

Figure 3.3. A student has explained the potential consequences of elevating blood sugar by eating high glycemic index snacks, i.e. candy, before going to sleep for people with genetic predispositions for melatonin sensitivity.

Instruments of Chemistry:

Practice explaining things to others to solidify new knowledge in your mind. If we understand something, we should be able to state it in simple words, but we must be careful not to oversimplify a description to the point where we lose the ability to distinguish it from anything else.

Over the previous weeks of lecture, we have learned about several instruments and techniques that chemists use to characterize chemical compounds. Explain in simple terms how mass spectrometry (MS), infrared spectroscopy (IR), and nuclear magnetic resonance spectroscopy (NMR) work to a friend or family member. A picture is worth a thousand words so feel free to draw in your journals to better explain yourself.

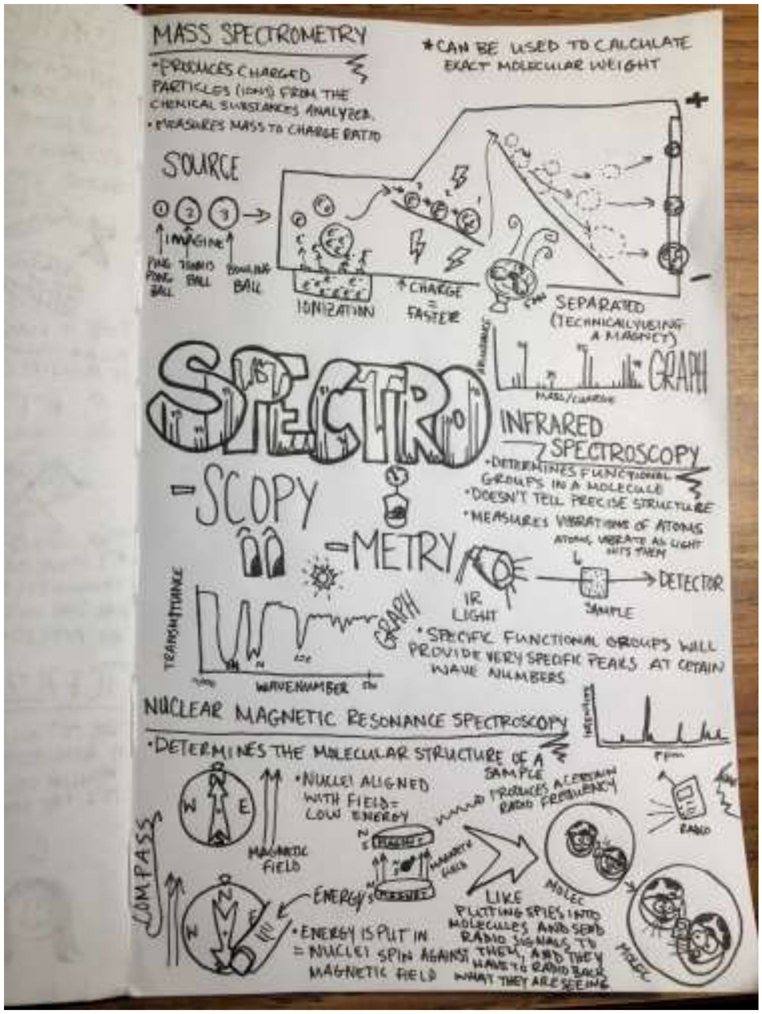

Figure 3.4. A student has demonstrated their blossoming knowledge of MS, IR, and NMR by describing these techniques in language that a friend or family member could understand.

The journal assignments illustrated above are among some of the artistically best decorated works created by students especially artistically inclined. Some students reported feeling nervous about their weak artistic skills. However, these artistic journal entries were not graded for artistic capability, instead the art used in these journal entries was graded on perceived effort. Further, students that were less artistically inclined tended to use images from the internet to illustrate their journal entries.

The grading rubric used for these journal assignments in CHEM 232 focused on the accuracy of the explanations written by students. Students were required to read curated relevant research articles and other resources available online in order to explain organic chemistry principles such as double bonds and fatty acid desaturation to a common audience of family and friends or hypothetical patients in a physician's office. An example of the grading rubric used for the Fall 2018 semester can be seen below:

Legibility of the journal entry: 2 points

- Is your journal completely legible?
    - +2 points
- Is your journal impossible to read?
    - Edit your journal entry and resubmit. You will get no credit until it is legible.

Academic rigor: 2 points

- Does it look like you spent time and effort to make a quality journal entry?
    - +2 points

Clearly answering the prompt: 3 points

- Are your answers to the prompt easily identified?
    - +1 point
- Are your answers to the prompt correct?
    - +2 points
    -

Artistic expression: 3 points

- Does it look aesthetically pleasing? (you don't have to be a great artist, but you do have to try!)
    - +1 point
- Did you effectively use drawings/figures that connect with your text?
    - +2 points

If your journal is legible, rigorous, correct, and artistic, then you get a full 10 points!

Discussion:

Instead of being assessed with quizzes, exams, and homework, which can be a dead-end assessment that gets thrown into a trash can or recycle bin three years after completion, a handmade journal is something that students can keep with them and can be shared with future generations of students as a growing body of work to which students may contribute.[17] When students go on to biochemistry or genetics courses, they can look back to the journal and make connections to their general and organic chemistry classes.

Students took ownership of their projects, however, some students found it overwhelming to have to undertake such an open-ended journal and pick something unique and creative to write about. This open-endedness worked for some students but not all. For the most part, students enjoyed replacing homework assignments with keeper assessments like the journal entries. However, some students felt that the open-ended nature of the journal was somewhat overwhelming, and therefore some students felt pressured to quickly put together and submit unthoughtful entries. When requesting that students keep a journal, it is important to emphasize the learning value that comes from taking the time to organize thoughts into a journal. While many students will be excited to log their knowledge in an artful journal, other students may be nervous about their ability to be artistic or may be skeptical that they are learning anything from journaling. Overall, journaling in CHEM 199 allowed for students to expand upon and take ownership of the topics covered in class by arranging visuals in their journals to make learning personal. A video interview of a student's perspective on the CHEM 199 journals is available on Illinois Media Space.[18]

Conclusion:

Great learning experience for some students, but other students had difficulty completing and connecting with such an open-ended assignment. Open-ended prompts allow students to take ownership of course content and practice learning in the wild. However, grading open-ended journals becomes a bit problematic and time consuming with regards to assessing gained knowledge. Since these journals are intended to serve as renewable assessments, prompts need to provide a little more scaffolding to make grading process more uniform and facilitate scaling up to a larger class.

Overall, journaling helped students realize that learning, like living, is all about the journey, not the destination. In both classes, students watch a brief video on the life of Dan Eldon, the youngest journalist to become a reporter for Reuters, and are encouraged to be honest and thoughtful when preparing their journal entries.[19]

Acknowledgements:

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CHAPTER 4: STUDENT WELLNESS COALITION

Nurturing a Grad-Roots Movement to Decrease Mental Health Stigmatization and Improve Work Culture in a Chemistry Department at an R1 University

"You can cut all the flowers, but you cannot keep spring from coming"

– Pablo Neruda

Abstract:

In 2017, a grad-roots movement started within the Chemistry Department at University of Illinois Urbana-Champaign (UIUC) with the assistance of a student from the UIUC Department of Clinical Psychology with the goal of improving department climate and wellness. Data was collected with the permission of the Department Head of Chemistry at UIUC and a survey administered by graduate students from the Department of Chemistry Graduate Student Advisory Committee (DCGSAC). The data collected using this survey was compiled into a concise report, the Department of Chemistry Graduate Student Wellness Report 2017 and posted throughout the halls of the UIUC chemistry department. In response to the publication of this report, the chemistry faculty organized, amongst other responses, a mandatory meeting to discuss the implications of this report. Graduate students in the chemistry department worked with the momentum that resulted from the Department of Chemistry Graduate Student Wellness Report 2017 to form a coalition of graduate student organizations in order to fund and organize the inaugural Summer Lecture Series directed at fostering a diverse and inclusive environment to support mental health and wellness within the Department of Chemistry at UIUC. This grad-roots movement toward mental health continues the arduous work of seeking expert guidance to

promote mental health and wellness on campus and in graduate schools across the nation. It also catalyzed further action such as a Chemistry/LAS climate survey and eventually a Chemistry Action Plan to improve Climate and Diversity.

Introduction:

Mental health in graduate school is a nationwide problem that has not being properly addressed, although there has been a surge in addressing this issue in the past several years.[1–4] It is understood that poor mental health can deter academic and research performance.[5,6] Further, it has also been found that even when college students are aware of the availability of mental health resources, they do not properly or frequently enough seek them out likely due to the stigmatization of discussing mental health.[7] Given the severely one-sided power dynamic between graduate students and postdocs on one end, and faculty on the other end, one would expect faculty members to take the lead in addressing the mental health crisis among graduate students.[8] Unfortunately, leadership training is scant, if not non-existent, in academic research institutions[9] and the results of this void are felt most heavily by graduate students and postdocs.

This chapter documents the process of a grad-roots movement that started within the Chemistry Department at UIUC with the intention of changing workplace culture from the inside out. Inspiration for this approach came from a variety of sources, not all immediately obvious because, to the best of the author's knowledge, there does not exist a significant body of research or guidance in starting cultural movements from the inside out within a graduate school department at research universities. One source of inspiration is Henderson's review of changing faculty opinions on instructional methods, which demonstrates the importance of gathering data on effective instructional methods, presenting those methods with the data to fellow faculty members, and regularly encouraging and requesting faculty cooperation in reforming a department's instructional practices.[10]

In 2017, a grad-roots movement led by graduate student leaders in the Department of Chemistry Graduate Student Advisory Committee (DCGSAC) started within the Chemistry Department at University of Illinois Urbana-Champaign (UIUC) with the assistance of a student from UIUC Department of Clinical Psychology. The study was modeled after a previously ongoing study of depression and anxiety among the graduate students which was performed in collaboration with the University of Illinois' College of Engineering Graduate Program.[11] DCGSAC decided to implement this study in the UIUC Chemistry Department because up until that point, the discussion of graduate students' mental health relied almost entirely upon anecdotes and personal empiricism, in much the same fashion that some early chemistry education research was conducted in past decades.[12] The survey implemented in the Chemistry Department in April 2017 was composed of questions from the Depression Diagnostic and Severity Measure (PHQ-9), the Generalized Anxiety Disorder measure (GAD-7), and the Patient Health Questionnaire.[13–15] The survey was conducted, data was collected, and results were presented per IRB Protocol #16690 in April of 2017.

After collection of data, DCGSAC proceeded to prepare a report of findings from the survey included aggregate data from the PHQ and Anxiety scale inventories as well as free response items that were representative of the categories of responses that were received. Very careful attention was paid to present only data that was very unlikely to identify the author, as this is a serious concern in situations with close workplace environments where specific people's language could be tied back to the author. These results were posted in the hallways of the chemistry department buildings and were also released via email by the chemistry department.

At least one mandatory faculty meeting was organized in response to the posting of this survey. The department's response to the results of this survey were not formally documented but they were highly interesting. Future work regarding surveys of the like may want to consider collecting data on the response to survey results as this would be useful for the literature of change management theory and practice in academic settings.

The third phase of this movement was organizing graduate student committees together to ride on the momentum of the survey and create lasting change. In the wake of the mandatory faculty meetings, graduate students from several different graduate student organizations associated with the chemistry department banded together with the intention of creating a new type of organization that could focus on improving wellness culture in the chemistry department. At the time, forming an organization with the goal of improving culture within a department was unheard of. UC Berkeley and University of Minnesota had previously worked on surveys and reports of graduate student mental health and served as a bit of inspiration for the grad-roots movement at UIUC.[16–18] At first, graduate student representatives from these organization met in secret to preserve their anonymity and status within the department. By the end of the Fall 2018 semester, this organization of students would take an overt leadership position in supporting faculty member's transition into better management practices. In 2019, the UIUC Chemistry Department formed a Diversity Committee and Climate Committee which include graduate student leaders and devised a Climate and Diversity Action Plan[19] to continue strengthening the workplace climate within the UIUC Chemistry Department. The grads-roots movement eventually took the shape of the Student Wellness Coalition (SWC), as they would be called, and currently works closely with the Diversity Committee and the Climate Committee to steadily progress towards an improved culture of health and wellness within the chemistry department.[20]

Results:

145 out of 304 graduate students responded to the survey. The data revealed at least 41 graduate students over the threshold for depression and/or anxiety, as seen in Figure 1. In response to these data, the Department of Chemistry planned to place more emphasis on ensuring graduate students have regular access to wellness professionals. This included the establishment of a monthly time reserved for a graduate student support group run by a professional through the Counseling Center. Principal Investigators (PIs) are highly encouraged to allow students time attend to these events as well as seek any other help they may need.

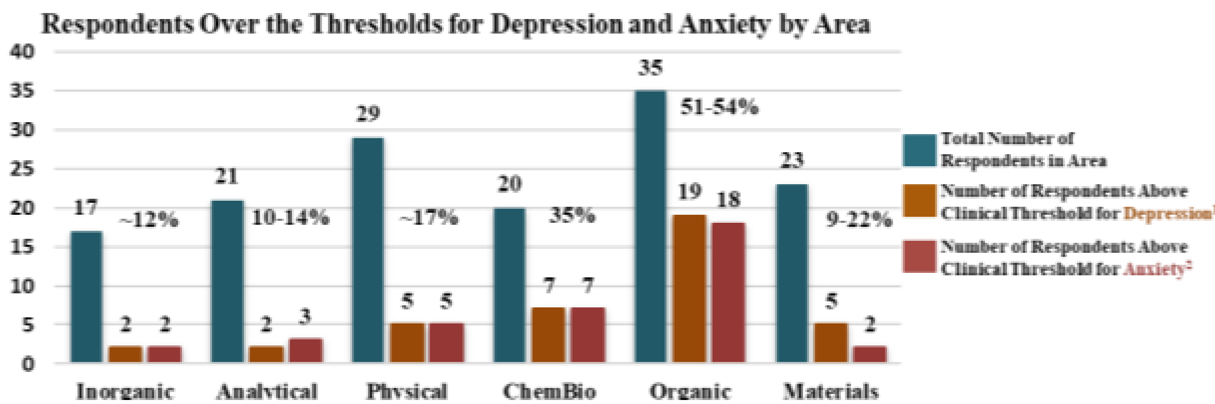

Figure 4.1. Results of the DCGSAC survey administered in April 2017.

According to the Job Demand – Control – Support model revised in 2015,[21] the key contributor to the stress that causes or exacerbates these levels of depression and anxiety, may likely be the lack of job control on behalf of the graduate students and the lack of social support in the laboratory. Of course, graduate research is inherently difficult and stress-inducing, but faculty have the unique position to significantly influence their workplace culture by setting an example for collegiate interaction. Further, the nature of the advisee-adviser relationship is unidirectional, given the steep power-dynamic. This is illustrated by the free response answers shared below:[22]

Training for Advisors/Mentors

Many participants felt their advisors had not received enough formal training in being effective mentors, or in approaching a student about mental or physical wellness concerns in a productive fashion.

Representative quote: "In some cases, [faculty] try to motivate students by insulting them, creating hostile lab environments, being passive aggressive, and other damaging tactics."

Lack of Accountability for Advisors

A perceived lack of accountability on the part of the PIs was common. Some students felt their concerns could not be effectively voiced without fear of reprisal.

Representative quotes: "Faculty have too much power over their students and there is no system in place to stop advisors from mentally and emotionally abusing their students..."

"My committee doesn't seem to be invested in guiding my education. Professors have either not been present or disengaged for events such as my literature seminar or prelim exam."

Discussion:

The results of the survey painted a harrowing portrait of the depression and anxiety rampant within the UIUC Chemistry department, and specifically within the areas of organic chemistry and chemical biology. The free response answers to the survey insisted that the source of depression and anxiety within the department and these areas was the poor, and sometimes intentionally abusive, management styles of some faculty members within the chemistry department.

Presenting the results of this survey created an acute response felt throughout the UIUC Chemistry Department. As such, a mandatory faculty meeting was held to address the results presented in report that was posted along most trafficked portions of the hallways in the chemistry department. Included in the Department of Chemistry Graduate Student Wellness Report 2017 was the following message from the Department of Chemistry:

> “The Department of Chemistry is seeking to implement new training for PIs with a specific focus on personnel management. The goal of the training is to help students and PIs address expectations and frustrations in a more productive manner. The department will also test two approaches for improved PI training and awareness of mental health: a campus expert on student mental health and related issues will be invited to faculty meetings on a regular basis. This has not been done in the past. In addition, the new Assistant Director of Graduate Diversity and Climate, who is in regular contact with students as an ombudsperson (an impartial intermediate), will prepare anonymized feedback for faculty, subject to approval from the students in contact.”

The graduate students, of course, were also in a stir about what to do next. Amongst the graduate students there was an air of frustration and impotence that resonated among many graduate students. No data was collected on the response to the survey. Only anecdotal evidence can be shared regarding the response of the graduate students to this Department of Chemistry Graduate Student Wellness Report 2017. Some graduate students were upset that not enough was being done to address the issues outlined in the report. At the other end, graduate students were upset that time and resources were being diverted to address the non-existent and irrelevant goal of improving culture within the department. What is documented, is the coordination of a small contingent of graduate student organization representatives with the intention of (1) bringing awareness to the depression and anxiety within the department and (2) implementing changes to improve the mental health and wellness within the department.[20] This contingent of graduate student leaders formed the Student Wellness Coalition and created the mission statement below to unify their actions:

> "The mission of the Wellness Coalition is to support the graduate students and post doctorates of the UIUC Chemistry Department in minimizing and mitigating the undue stress from research-related activities. We aim to: (1) Identify and address the sources of undue stress; (2) Provide holistic, compassionate, and practical resources for all aspects of academic life; and (3) Foster an empathetic research community."

With the intention of bringing awareness to the mental health concerns of the UIUC Chemistry department, the Student Wellness Coalition organized a series of seminars delivered during the Summer 2018 semester. Summer 2018 was selected as the ideal time for such a series because most graduate students would be available on campus with minimal commitments to classes or other duties other than research.

Within the field of organizational psychology, it is well understood that the weakest link within an organization is the human component.[23] When an organization repeatedly falls apart it is good practice to identify the weak points in that system which place too much pressure on the decision-making ability of the humans involved in that part of the system. Within the UIUC Chemistry Department, there are arguably several weak points because graduate studies, especially in the sciences, is inherently stressful. Mental health and it is exacerbated by poor mentoring, but even in groups with excellent mentors there are mental health issues. That being stated, one weak point of interest, which has in recent years begun to be addressed, may be the absence of any sort of management training required by research or instructional faculty members which applies a, yet unquantified, but arguably enormous, amount pressure upon research faculty to develop their own best practices for laboratory management.[2,24–26] Without the proper support system in place, it is possible, and evident, that faculty may enact best practices that can create a workplace environment that is detrimental to the mental health and wellness of its constituent graduate students.

Of course, other factors are very likely to weigh into the equation of mental health and wellness for graduate students, post-doctoral researchers, staff, and faculty. One of these factors may be the uncertainty which is characteristic of research. The SWC and Climate Committee, which include student, postdoc, staff, and faculty members, have helped reduce uncertainty through the development of lab manuals for many groups. Previously, some labs had lab manuals, some labs had virtually inaccessible lab manuals due to the sheer volume of information that was stored and unprioritized within them, and some labs had no lab manuals.

Also, the Department of Chemistry is working on enacting a Personal Time Off policy for students in the department, which at the time of writing this dissertation has been approved, but not yet released. This Personal Time Off policy is expected to help reduce stress and anxiety on graduate students, which have previously had widely variable time off policies, depending on their lab.

To address the absence of management training for faculty members, in accordance with frequent recommendations from the SWC, in Spring 2019 the UIUC Chemistry department began requiring research faculty members to attend at least 6 management training sessions or seminars. In 2019 Kate Clancy, a champion of improving workplace culture in research institutions,[27] began offering "Inclusive Lab Leaders" management workshops specifically to address the absence of management training amongst faculty members across the UIUC campus. The SWC also included seminars in its annual Summer Lecture Series that were designed to provide positive and productive management training and resources for graduate students, staff, and faculty in research laboratories. Finally, the department began continuing training sessions for faculty as part of faculty meetings (e.g. Daniel Wong on mentor-mentee relationships), as well as online training ranging from improved management to COGNITO training, among others.

Conclusion:

In April 2017, DCGSAC members created and implemented the first survey of workplace depression and anxiety in the UIUC Chemistry department with the assistance of Dr. Michael Kruepke, who was a doctoral student at the time. The results of this survey were compiled into a report with the support of the Chemistry Department Head and was distributed to the entire chemistry department at the start of Fall 2017.

In mid-Fall 2017, representatives from several graduate student organizations connected to the UIUC Chemistry department banded together with the common goal of improving workplace culture for graduate students in the UIUC Chemistry department. With minimal support or guidance from the Chemistry Department, this grad-roots movement used their existing funds to organize a Summer Lecture Series in Summer 2018 to bring awareness and training to address the concerns highlighted in the 2017 Health and Wellness Report.

In Summer 2019 the second annual Summer Lecture Series included more training and resources and gathered a much larger audience than the previous year. Excellent graduate student leaders are rising to the call of improving wellness culture in the UIUC Chemistry Department. Following the 2017 climate survey and report, SWC and the Climate committee are moving forward with recommendations that are being implemented by the Department of Chemistry.

In the words of Nipsey Hussle, “I say it’s worth it, I won’t say it’s fair.”[28] The journey toward doing better to create a diverse and inclusive workplace within a graduate school at an R1 university will take graduate students, postdocs, and faculty members through many uncomfortable conversations.[29] Avoiding this journey will stagnate the social progress of the university. Navigating this journey together will make the UIUC Chemistry Department a positive role model for other institutions on their own journeys toward diversity and inclusion.

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CHAPTER 5: EMPATHIZING TO LEARN AND LEARNING TO EMPATHIZE

"I feel like I have to tell you, you have something to contribute"

– Nipsey Hussle

Abstract:

The findings described in Chapter 4 suggest that depression and anxiety may, at least in part, be the result of insufficient or nonexistent management training for research advisors. The unique relationship between mentors and mentees in a research university consists of a steep power dynamic which may instill a sense of impotence over graduate student's job control and may exacerbate preexisting mental health conditions. This work heavily influenced the author's previous perspective on undergraduate education and the influence that instructors have on their students' classroom engagement and mental health. This current chapter presents the need for empathic communication training for instructors of undergraduate courses, including gateway courses, such as introductory chemistry. A research plan is proposed for the development of a text classification tool for measuring and analyzing empathic communication in written assignments. Currently, the data collection for training this text classifier is underway.

Background:

The hypothesis of the initial HHMI study was that making the molecular sciences personal will improve curiosity, interest, and learning outcomes.[1–4] We tested this hypothesis with a multi-semester intervention consisting of project-based group research in General Chemistry 2, and role-play journal assignments in Organic Chemistry 1 and Organic Chemistry 2. We conducted focus group sessions with students to investigate if the project-based group research and journals, which are commonly used as pedagogical tools,[5,6] were effective at making abstract chemistry content personally meaningful. In focus groups 1 and 2 years after subjects completed Organic Chemistry 2, attendees strongly agreed that the journals were highly memorable experiences, helped them make real-world connections to chemistry, and even motivated students to change their and their families' diets and fitness habits. These results exceeded the initial expectations of the journal assignments. We planned to scale up the journal assignments for larger classes, but this would require dedicating large amounts of time for grading. We consulted Professor Roxana Girju, an expert in computational linguistics at the Beckman Institute for the Advancement of Science and Technology, in search of software that would consistently and reliably grade journals. To our knowledge, no such software exists, so we planned to create a program to do this. After discussing our goals further, we realized these journal assignments were rich in empathy and comprised a highly unique and potentially useful dataset for addressing knowledge gaps in the study of empathic expression.[5,7,8]

In addition to their potential to create a dataset with enough empathic communication to possibly train a text a classifier to serve as a research tool to better understand empathy, these journal assignments may also serve as a targeted intervention to further harness utility value in pre-medical students enrolled in introductory chemistry classes. In 2015, the Association of American Medical Colleges (AAMC) updated the Medical College Admission Test (MCAT) to include a test section on social and behavioral sciences, reflecting the growing interest in preparing undergraduate pre-health students for the social and behavioral training in medical school.[9] As such, it is expected that a written assignment in which students are prompted to explain introductory chemistry concepts to a hypothetical layperson in empathic and approachable language would have perceived utility value for premedical students for two reasons. First, students will be able to practice explaining abstract chemistry concepts to a hypothetical patient, thus illustrating the utility value of chemistry concepts. Second, students will be able to practice empathic communication of this abstract information, thus illustrating the utility value of empathically communicating technical information.

Research on how to decode human behaviors with respect to empathy expression, perception and action is still in its early stages, partly due to physical constraints on acquiring large amounts of data of students' behaviors against empathy evaluations. In empathy analysis, the availability of reliable data is currently the main limiting factor[10] in both quantity and variety. Most existing works have focused on audio recordings from a few large-scale psychotherapy studies and counseling therapy sessions[11] totaling to thousands of sessions; however, only a small fraction has been finely annotated focusing mostly on speech[10], rendering such datasets insufficient for the purposes of training and evaluating an artificial intelligence driven approach to detecting empathic expressions in text. Additionally, despite the abundance of theoretical research on empathy, there is currently a lack of objective, data-driven measures of empathy as a psychological and socio-behavioral phenomenon and its indicators in linguistic expression. The absence of adequate training data and objective measures of empathy poses substantial limitations for the design and implementation of any large-scale approach to empathy detection in text and would need to be addressed before any such systems could be built and validated.

Hypotheses:

The aim of this research is to investigate the potential impact of empathic expression in the chemistry classroom to improve students' curiosity, interest, and learning outcomes in chemistry. To answer this question, we must address a knowledge gap that exists in consistently measuring empathic expression in language. Empathy scoring is typically done using questionnaires or via interviews. Our computational linguistics approach will use machine learning to consistently and objectively score empathic expression in text communication. We will measure the success of our research by testing these hypotheses:

1. **Empathy analytics** - Empathic expression is quantifiable using machine learning methods.
2. **Learning to empathize** - Empathic expression is a skill that improves with experience and training.
3. **Empathizing to learn** – Written assignments encouraging better empathic expression increase task value, curiosity, and interest.

Methods:

In Fall 2019 and Spring 2020, ~2,000 journal assignments will be collected from large classrooms (300-500 students) of CHEM104 students. The journal assignments will be rich in empathic language and also high in utility value. For example, in one journal assignment students will (1) explain in layman terms the mechanism of action of a drug and (2) empathically break the bad news of diagnosing a patient with pharmaceutical therapy. These journal assignments will comprise a dataset that is pedagogically valuable for students and uniquely high in its empathic language content. This research project is approved by the UIUC Institutional Review Board (protocol #19742).

Pre-existing typewritten journal assignments composed by undergraduate students in a sophomore organic chemistry course at a large midwestern university will be collected, deidentified, and stored in a safe online database. These journal assignments are expected to have varying levels of empathic language use because the prompt for these assignments requires students to role play as physicians delivering a diagnosis to a patient. This journal writing assignment has pedagogical value for undergraduate students;[12,13] it is implemented as a means to boost student achievement in chemistry by affecting their interest and motivation in the subject.[2,3,14] A typical journal prompt and sample journal entry can be seen below:

> "After missing several appointments during the past few months, Joseph has returned to your office today concerned about his heart health. Calculate his risk of heart disease using the American Heart Association heart risk calculator. Provide Joseph with some dietary advice based on his current dietary intake of fats and your knowledge of fatty acid metabolism."

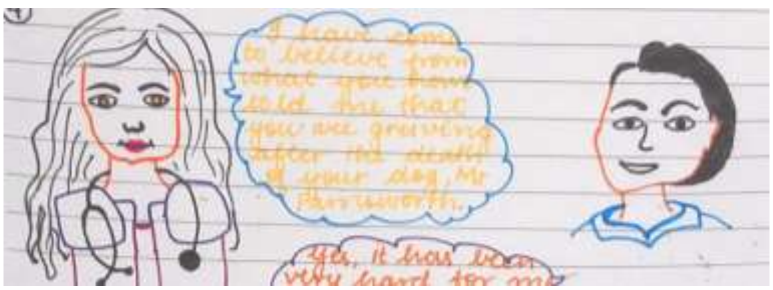

Figure 5.1. This student has drawn herself providing dietary advice and building a relationship with her hypothetical patient, Joseph.

These types of journal assignments have the potential to be high contextualizing and appealing to students due to the wide-open creative possibilities of artistic expression possible with multi-media written assignments. While these artistic expressions may contain a significant amount of empathy encoded within them, training an AI system to analyze and measure the empathy conveyed by art would be far outside the scope of the current work. Therefore, the current iteration of the sample prompts used to elicit an emotional and informative diagnosis for a hypothetical patient asks students to generate a typed essay. An example of the current prompt can be seen below:

Scenario:

"John is 35 years old, has a spouse, and two kids (ages 10 and 8). John's bloodwork has revealed that his cholesterol is dangerously high. John will require statin therapy and may benefit from a healthier diet and exercise."

Prompt:

Explain to John how statin therapy will affect his cholesterol. Consider answering any questions John may have.

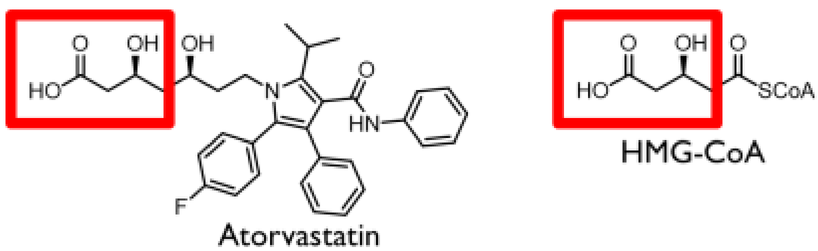

Figure 5.2. Atorvastatin is a typical cholesterol-reducing drug that is designed to inhibit the mevalonate pathway, a critical metabolic pathway that involved in the biosynthesis of cholesterol. Atorvastatin is capable of inhibiting HMA-CoA Reductase, a bottleneck enzyme in the mevalonate pathway, because of the structurally similar portion highlighted in red on both molecules.

The educational relevance of this written assignment for a general chemistry classroom is twofold. First, a significant portion of the typical General Chemistry 2 curriculum revolves around understand the properties of acids and bases. The highlighted portion of atorvastatin and HMG-CoA contains a carboxylic acid functional group which has a pKa of approximately 5. The pH of the human body ranges from 1.5 to 3.5 in the stomach, up to 7.4 in the blood. Therefore, this carboxylic acid may have a neutral charge in the stomach and a negative charge in the blood and most other cells. This direct connection between human physiology and acid/base chemistry provides an opportunity for students to make real world associations with otherwise abstract chemistry concepts. Second, a significant portion, approximately 50%, of the student population that commonly takes CHEM 104 at the University of Illinois Urbana-Champaign are pre-medical students.

Codifying Empathy:

Codifying empathy is a significant challenge of this study. Several survey instruments exist and are commonly used to assess physician empathy in patient consultations and experiences.[15–17] The initial plan for codifying empathy in text focused on selecting the most prevalent and the most text-appropriate survey of physician empathy to serve as a guide for identifying instances of empathy in the collected journal writing assignments. Of these survey instruments, CARE Measure may serve as the most effective measure to develop a proof of concept text classifier as it is prevalent in-patient experience ratings and it is the shortest.[17] The CARE Measure is a 10 question-survey filled out by patients to rate their physician consultation on a 5-point Likert scale. These surveys address the components of empathy according to the medical literature, shown in Figure 5.3, however, the Empathy in Text classifier will be limited to recognizing empathy expressed strictly through text communication.

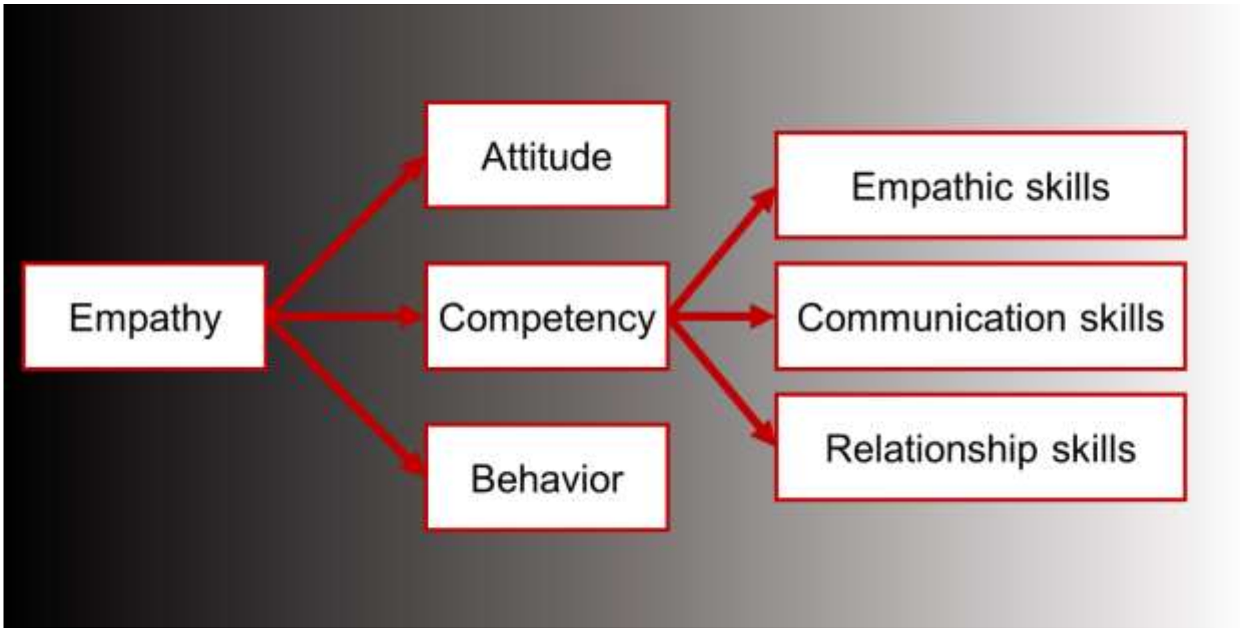

Figure 5.3. Schematic representation of the components of empathy[5]. The Empathy in Text tool may serve to improve students' empathic and verbal communication skills.

Supervised machine learning, training a machine with labelled data, will be the key process involved in training this text classifier. In this process, human annotators will annotate the training set portion of the corpus according to the CARE Measure, as shown in Figure 5.4. Based on the human annotators' labelling, the text classifier will learn to recognize parts of the text that match elements of empathy in the CARE Measure. After training, the classifier will label the testing set data to indicate portions of text that demonstrate elements of empathy. If the human annotator-text classifier agreement is equal to or greater than the human annotator-human annotator agreement, then this proof of concept model will be considered successful.

CARE Measure:
How was the doctor at…

- Being interested in you as a full person?
- Making a plan of action with you?
- Helping you take control?

I'm sorry to hear about Prof. Farnsworth. When my dog passed away it was really hard. What helped me was finding strength in friends & family and talking about how I was feeling. Events like these can cause us to make changes in our lifestyle that might make the difficult time even harder. Keep on coming to check-ups, try to stick to our new plan, and we'll go from there one step at a time.

Figure 5.4. This is a sample of text from an actual journal assignment. Phrases are highlighted to match their corresponding questions elements of the CARE Measure. Underlined phrases may also serve to identify key terms that relate to the CARE Measure questions.

This initial attempt at codifying empathy presented a significant flaw concerning the difference in empathy definitions between the medical community and the social and behavioral science community. A major distinguishing point between these two communities is that the medical community considers certain care-related acts as empathic behavior which would be considered part of a physicians' expected professional care routine. For example, some instances of "Making a plan of action with you" may be part of a physician's duties, and not necessarily the result of a physician's empathic intentions. Therefore, a different definition of empathy is currently being used to identify instances of empathic communication. The current definition of empathy considers two aspects, cognitive empathy, a person's ability to accurately identify the emotional state of another person, and affective empathy, a person's ability to accurately feel the emotional state of another person.[18]

Reliability of training data will be measured using established practices in corpus linguistics. Once data quality has been validated, human and machine gold standards will be established for all the machine learning tasks defined in the project. The system's performance will be evaluated against those gold standards as well as against existing systems and methods in the literature. We will then perform extensive error analyses of our results to determine how the systems could be further improved.

Implications

Successful completion of each milestone in this project could have far-reaching impacts for the research community and the healthcare industry. A carefully collected and reliably annotated corpus of empathic text would by itself be considered an invaluable resource for the study of empathy as a psychological and socio-behavioral construct. Such a resource would also offer a unique framework within which one might examine and better understand the linguistic bases of empathy, as opposed to doing so from a purely theoretical standpoint. These resources could be exploited to train a language processing system that would be able to detect and evaluate expressions of empathy objectively, quickly, and consistently which could have very powerful pedagogical implications for training pre-medical students in particular and, more generally, for promoting better empathic communication in the healthcare industry.

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CHAPTER 6: BROADER IMPACTS & WRITING DURING A GLOBAL PANDEMIC

"More than one doctor told me that it was easier to get a new MRI machine than to maintain basic supplies and hygiene. Such machines have become the symbols of modern medicine, but to view them this way is to misunderstand the nature of medicine's success. Having a machine is not the cure; understanding the ordinary, mundane details that must go right for each particular problem is."

– Atul Gawande, Better: A Surgeon's Notes on Performance

The interesting thing about writing a dissertation on chemistry education during a global pandemic is watching the spread of fear that originates from not understanding some fundamental STEM knowledge. Without a doubt, these are incredibly stressful times for everyone in the world for several concerns ranging from physical health, economic, and social reasons. However, some of this fear may have been prevented if a greater number of global citizens understood some basic STEM fundamentals. As our species transitions into the science-fiction world of the 21st century, it is becoming more obvious that chemical literacy for everyone is a fundamental social responsibility of being a global citizen, just like learning to read, write, recycle, and vote. Developing vaccines and treatments are the exclusive responsibility of experts with specialized knowledge, but flattening the curve is the collective responsibility of every global citizen. Therefore, it is important that we all due our part to properly wash our hands, properly wear our face masks, properly social distance, and encourage each other to do the same. In the future, flattening the COVID-19 curve may hopefully serve as a model for global collective efforts to counteract other diseases.

Summary of Previous Chapters:

The work outlined in the first three chapters of this dissertation has illustrated existing obstacles in introductory chemistry education, focused on the potential of harnessing motivation in the college chemistry to overcome some of these obstacles, and presented possible interventions for emotionally engaging students. Chapters two, three, four, and five outlined ongoing research to explore methods of measuring empathic communication and potentially using this fundamental knowledge to train pre-medical undergraduate students and current medical students to engage their classmates and future patients with empathic communication to possibly increase academic performance, foster better community engagement with their colleagues, and someday enhance future patient outcomes. Chapter seven illustrated the origin of a grad-roots movement to transform the culture of an R1 university chemistry department. This chapter stands upon the mountain of knowledge demonstrated by these previous chapters and looks ahead for further research in education policy and empathic communication that may serve as the soil for sowing local community-based solutions to declining nationwide mental health.

Stress, Grief, and Empathy in the American Population:

The focus of this thesis has thus far been on harnessing pre-medical college students' motivation through emotionally engaging work to encourage meaningful learning so that they may effectively develop long-lasting molecular literacy and empathic communication skills. Hopefully, this work may contribute to better training for pre-medical college students in future introductory chemistry courses. However, the first-year enrollment of medical students in the U.S. was just shot of 22,000 in the 2018-2019 academic year.[1] It is certainly critical for medical students to have strong molecular literacy and empathic communication skills, but the need and importance of these critical skills extends far beyond this incredibly small contingent of the American, or even global, population. In the wake of the COVID-19 pandemic that has blanketed the writing of this dissertation, it is abundantly clear that all Americans, and all global citizens would benefit significantly from molecular literacy and empathic communication skills. Knowledge is power. Having a fundamental understanding of viruses and pharmaceuticals may serve to assuage the fears over COVID-19 that result from a lack of understanding the nature of this illness and its potential treatments. At the same time, effective and empathic communication from leadership, or the lack thereof, is capable of alleviating,[2] or exacerbating,[3] nationwide stress and grief.[4,5] In order to appreciate the significance of this previous sentence, it is important to take a brief walk through the history of stress and grief.

In 1950, Hans Selye published his seminal work on the behaviors resulting from non-specific stress, *Stress and the General Adaptation Syndrome,* in the *British Medical Journal*.[6] Selye, known as the 'father of stress research', first encountered the phenomenon that would later be termed 'stress' when he was a medical student at University of Prague. While monitoring patients on ward rounds, he noticed that patients with different illnesses expressed similar complaints. This intrigued Selye because up until this point in history, it was believed that signs and symptoms were related to specific illnesses. At this early stage in his career, Selye called the non-specific response to diverse terminal illnesses, such as such as looking tired, having no appetite, losing weight, preferring to lie down rather than stand, and not being in the mood to go to work, the "syndrome of just being sick".[7] He would later begin his research in endocrinology to better understand why different stressors elicited similar physiological responses, a concept he termed non-specific stress.

In 1969, Dr. Elisabeth Kubler-Ross published *On Death and Dying* based on her interactions with her terminally ill patients. In this publication, Dr. Kubler-Ross delineated the five stages of grief, or the Kubler-Ross model, which illustrated the sequence of emotional states experienced by terminally ill patients. As such, the Kubler-Ross model influenced the healthcare community to better understand and consider the emotions of their terminally ill patients.[8]

In 1992, Dr. Robert Buckman, Monty Python comedian & physician, published the book *How to Break Bad News* based on his experiences with terminally ill patients and his own personal near-death experience. In this book, Dr. Buckman presented the healthcare community with his method for delivering bad news to patients, known as the SPIKES (Setting, Perception, Invitation, Knowledge, Emotion, and Strategy) method. The SPIKES method was influential in the healthcare community and has since become incorporated into Western medical practice and understanding stress, grief, depression, anxiety.[9]

Heart disease is the number one cause of death worldwide, leading to over 17 million people dying of heart disease each year. While the contributors to heart disease are primarily considered to be genetic or nutrition-based, emotional processing should not be discarded as a potential contributor to heart disease. There is a two-way relationship between heart disease and depression.[10] With 350 million people suffering from depression worldwide, investigating and addressing the sources of depression may provide solutions for preventing heart disease-related deaths.

The prevalence of self-help, life management, and leadership literature is fueled by the multitudes of individuals seeking guidance to take control of their daily activities to enjoy more fruitful, peaceful, or otherwise better lives because life is stressful. Selye's discovery of stress in the 1950's marked the beginning of our species' journey to understand how to identify stressors and stress responses. In 1969, Kubler-Ross brought her research of terminally ill patients' response to the severe stress induced by dying to the attention of the healthcare community. In 1992, Buckman attempted to train his fellow physicians with a simple method of delivering bad news to patients and helping them cope with and emotionally process their stress-induced grief. Of course, it is important to train physicians and mental health professionals to emotionally support their patients, but with 350 million depressed people worldwide, there must be a parallel effort to disseminate emotional hygiene skills to the entire population. Think of Choose My Plate[11] run by the cast of Inside Out.[12] In fact, these such efforts are already being carried out by a very passionate contingent of artists. The prevalence of sad rap in America has been promoting the importance of self-love and self-care for over a decade now.[13,14] Music should certainly not substitute a consultation with a physical or mental health practitioner, for a large contingent of the American population it may be helpful for emotional processing and developing health literacy.[15]

Malcolm Gladwell makes a compelling argument for the key difference between the games of basketball and soccer. Malcolm purports that basketball is a strong link game, in which a team's success weighs heavily upon the talent of a single individual whereas soccer is a weak link game, in which a team's success is determined by its weakest player. Basketball, therefore, emphasizes the skill level of a single rockstar player while soccer relies on each player having a minimum skill level, because the weakest player is a clear target for the opposing team. Malcolm claims that education is like a weakest link game, in which the success of the team, our populace, relies heavily on the minimum training of each member.[16]

Public policy is the field in which our species has an enormous untapped potential to do a great amount of public good for several reasons. One example of this is the transformation of libraries from houses of public records into meeting places and the beating hearts of communities where myriad citizens have open access to congregate, share ideas, connect to the internet. Similarly, changing the policy around education and its purpose in society is necessary and holds an enormous potential to improve society for everyone. Making scientific breakthroughs in understanding stress, grief, and empathy is like buying a new MRI machine, but training the population at large to perform the ordinary, mundane tasks of helping each other cope with stress and grief will save lives.

Concluding Remarks:

My work in founding the Student Wellness Coalition which began in 2017 preceded and heavily influenced my work in developing a linguistic modeling tool to identify empathic communication in text. While the empathic communication measurement tool is primarily being developed to accompany survey instruments for measuring interest in chemistry, it has also been the beginning of addressing a much larger and deeper issue that I have identified in the professional educational community. This issue is at the core of a modern organizational behavior literature that has been addressed by texts such as Radical Candor, which intends to provide its readers with tangible methods of expressing critical feedback and technical guidance through an empathic mode of communication. Indeed, the author seems to understand the importance of empathic communication in eliciting desirable outcomes for leadership and subordinate members of an organization.

The publication of Radical Candor recognizes a clear need amongst the most prolific and resilient leaders of our species for guidance in empathic communication within a professional organization. Naturally, this need can be extrapolated and generalized to leadership within professional organizations responsible for scientific research and the education of our planet's youth. In other words, I am convinced that university leaders are, or should be, interested in developing their empathic communication skills in order to best serve and guide their research staff and students. Indeed, only by providing empathic communication training for educational leadership can we consider confidently claiming our position as a proud source of academic enrichment for our population. However, only a third of American’s population has a college degree. This leaves most of the American population in the dark regarding a highly valuable skillset capable of transforming people's lives by facilitating genuine, empathic communication.

In the midst of our species’ first global pandemic, many of us feel the incapacitating weight of stress, grief, and fear. This fear is further exacerbated by the lack of empathic communication training for each member of our population, because fear, after all, is an emotionally contagious phenomenon that is capable of infecting through verbal and textual media,[17] whereas the coronavirus is merely airborne.

We are currently 70 years beyond three discovery of stress and grief, and only in the past 5 years has the importance of dealing with stress and grief permeated out from medical and professional organizations into the conscience of the general population. This is evident from the recent prevalence of popular culture emphasizing the importance of self-love and self-care. The presence of self-love rhetoric in pop culture is indicative of Hans Selye’s, Elizabeth Kubler-Ross', Robert Buckman’s, and countless others’ work finally being widely disseminated to the contingent of the population that needs it most – everyone.

I hope that we may learn from our predecessors that worked diligently to bring the skills of processing stress and grief to the common person. If we learn from these predecessors, then I hope young artists will disseminate the importance of empathic communication to the general population much sooner than the 70 years it took for artists to disseminate the importance of preventing and processing stress and grief.

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APPENDIX: SUPPLEMENTAL INFORMATION

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Demographic Information

Would you describe yourself as a health "pre-professional" student, where "pre-professional" includes pre-medical, pre-dental, pre-pharmacy, and pre-veterinary?

Yes
No
I haven't decided.

In this course, you had the opportunity to be genotyped and the option to use your genetic as part of various class exercises. Being genotyped was NOT a requirement for enrollment in this course. What did you decide?

I was genotyped. → *The next portion will appear.*

I was not genotyped. → *The next portion will not appear.*

> **How would you describe your use of your personal genetic information in this course?**
>
> I used my personal genetic information almost always (> 75% of exercises).
>
> I used my personal genetic information often (50% to 75% of exercises).
>
> I used my personal genetic information sometimes (25% to 50% of exercises).
>
> I used my personal genetic information almost never (1% to 25% of exercises).
>
> I never used my genetic information at all.

How useful was the genomic information for your learning the chemical concepts that were taught in this course?

1 = Not at all useful 2 = Somewhat useful 3 = Very useful 4 = Extremely useful

Epistemic Curiosity Questionnaire

I/D Scales

A number of statements that people use to describe themselves are given below. Read each statement and then select the appropriate response using the scale below to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer that seems to describe how you generally feel.

1 = Almost Never 2 = Sometimes 3 = Often 4 = Almost Always

1. I enjoy exploring new ideas.
2. Difficult conceptual problems can keep me awake all night thinking about solutions.
3. I enjoy learning about subjects that are unfamiliar to me.
4. I can spend hours on a single problem because I just can't rest without knowing the answer.
5. I find it fascinating to learn new information.
6. I feel frustrated if I can't figure out the solution to a problem, so I work even harder to solve it.
7. When I learn something new, I would like to find out more about it.
8. I brood for a long time in an attempt to solve some fundamental problem.
9. I enjoy discussing abstract concepts.
10. I work like a fiend at problems that I feel must be solved.

Scale	Sum the following items:
5-item *Interest-Type epistemic curiosity scale*	1, 3, 5, 7, 9
5-item *Deprivation-Type epistemic curiosity scale*	2, 4, 6, 8, 10

See Litman (2008) for normative scores

Thank you for participating in our research study on using genotyping in chemistry classes. Now that CHEM 332 is nearing completion, we welcome your feedback on your learning experiences during your CHEM 104 ("Intro to Chemistry") class, your CHEM 232 ("Organic Chemistry I") class, and this CHEM 332 ("Organic Chemistry II") class.

Our goal was to build a strong foundation of molecular understanding and scientific reasoning skills. Please take a few minutes to think back on your CHEM 104, 232, and 332 classes and then answer the following questions.

1. Are you going to take either MCB 354 ("the Biochemical and Physical Basis of Life") or MCB 450 ("Introductory Biochemistry") before you graduate?
   A. Yes, I'll take MCB 354.
   B. Yes, I'll take MCB 450.
   C. No, I'm not taking either.
   D. I'm not sure yet.

2. How prepared do you feel you are for a Biochemistry course next semester?
   A. I feel extremely well-prepared.
   B. I feel adequately prepared.
   C. I feel somewhat prepared.
   D. I feel ill-prepared.
   E. I don't know.

3. To what extent do you believe that these 3 experimental classes (CHEM 104, CHEM 232, and CHEM 332) have contributed to the following:

   - your understanding of molecular processes?
     A. To a great extent
     B. Somewhat
     C. Very little
     D. Not at all
   - the development of your scientific reasoning skills?
     A. To a great extent
     B. Somewhat
     C. Very little
     D. Not at all

- Your ability to read/extract important information from scientific literature?
    A. To a great extent
    B. Somewhat
    C. Very little
    D. Not at all

- your preparation for a preprofessional exam, such as the MCAT, PCAT, DAT, etc.?
    A. To a great extent
    B. Somewhat
    C. Very little
    D. Not at all

4. As you reflect upon the CHEM 104 poster project from the perspective (knowledge and skills) that you have now, to what extent do you agree with the following statement?

    "When you have to make sense out of messy information
    and then explain it to yourself or to others, meaningful learning occurs."

    A. Strongly agree
    B. Somewhat agree
    C. Somewhat disagree
    D. Strongly disagree

5. Briefly describe one activity or discussion topic that made a significant positive impact on you and your learning.

6. Briefly describe one activity or discussion topic that did NOT enhance your learning. Please add a suggestion for how it could be improved.

Interest Questionnaire

Four-Phase Interest Development in Chemistry (FPIDC) Questions

1 = Strongly Disagree

2 = Disagree

3 = Disagree Somewhat

4 = Neither agree nor disagree

5 = Agree somewhat

6 = Agree

7 = Strongly Agree

1. I enjoy learning about chemistry even when it is very difficult.
2. When I'm working on something in chemistry that I think is interesting, I continue working even when it takes a lot of time.
3. I work on chemistry projects outside of school at least once a week.
4. I always learn more about chemistry on my own if I find it interesting.
5. Knowing about chemistry is extremely valuable to me.
6. I think everyone should know a lot about chemistry.
7. I think of my own chemistry projects at least once a week.
8. I'm inspired to come up with my own chemistry projects to work on when I see something in chemistry that interests me.
9. I know way more about chemistry than other kids I know.
10. I know a lot about the chemistry topics that I find interesting.
11. Compared to other students at my school, I am better at doing chemistry work.
12. When chemistry interests me, I am confident that I can learn about it extremely easily.

Utility Value (UV) Questions

1 = Strongly Disagree

2 = Disagree

3 = Disagree Somewhat

4 = Neither agree nor disagree

5 = Agree somewhat

6 = Agree

7 = Strongly Agree

1. I can apply what we are learning in chemistry class to real life.
2. I think what we are studying in chemistry class is useful to know.
3. I can see how what I learn from chemistry applies to life.

Intention to Pursue Chemistry Questions

1. I intend to continue taking chemistry classes.
2. Do you intend to take Organic Chemistry 1 (CHEM 232)?
    a. If not, why not? (check all that apply)
        i. It is not required for my major / program
        ii. It is not relevant to my career aspirations
        iii. It will lower my GPA
        iv. I do not enjoy chemistry
        v. Other_____

3. Do you intend to take Organic Chemistry 2 (CHEM 332)?
    a. If not, why not? (check all that apply)
        i. It is not required for my major / program
        ii. It is not relevant to my career aspirations

iii. It will lower my GPA

iv. I do not enjoy chemistry

v. Other_____

4. Do you intend to take Introductory Biochemistry (MCB 354 or 450)?

    a. If not, why not? (check all that apply)

        i. It is not required for my major / program

        ii. It is not relevant to my career aspirations

        iii. It will lower my GPA

        iv. I do not enjoy chemistry

        v. Other_____

FPDIC and Utility Value ANCOVA Summary

Interpretation and Notes

This document contains descriptive statistics and results from an analysis of covariance (ANCOVA) of all utility value (UV) and interest questionnaire (IQ) scores. The analysis of covariance tests the difference between experimental and traditional group end-of-semester (EOS) scores after controlling for the beginning-of-semester (BOS) scores. Below are some guidelines and points of importance for interpretation of results.

Effect Size

Effect size signifies whether an observed statistically significant difference is large enough to be meaningful. Effect size is represented as Cohen's *f* for statistically significant results. Effect sizes are considered small, 0.1 to 0.25, medium, 0.25 to 0.4, and large, 0.4 or greater.

Standard Deviation

When thinking about group differences and change in scores, compare these values to the standard deviations presented in the **Sample Descriptive Statistics** for the appropriate course to get a sense of the magnitude of the difference. For instance, a mean group difference of 7.46 is less than 50% of a standard deviation for standard deviations values 15 or higher.

Power

Power of a test is the probability that the test correctly rejects the null hypothesis. Where results are not statistically significant, achieved power (1- β error probability) is reported. Typically, a power of 0.80 or larger is desired.

Group Differences Vs. Change in Score Over Time

After Sample Descriptive Statistics, there is a bar graph that shows the mean score for each group and time point for every scale or subscale. It is important to note that the ANCOVA represents the difference in end of semester scores between the experimental and the traditional groups after controlling for beginning of semester scores of the participating students**. It does not indicate whether or not there is a change in score from BOS to EOS.** This change for each group is indicated with an asterisk (*) in the Sample Descriptive Statistics table. The change in mean scores are typically very small relative to the standard deviation and overall score, as shown in the bar charts.

ANCOVA with Interaction

A model was fit with the interaction between BOS score and group membership for all scales and subscales for each course. These interaction effects were insignificant except in two cases; IQS1 – 332 and IQS2 – 104. The model with the interaction is not presented when it was non-significant. In these two cases the results with and without the interaction are reported with model R^2 and RMSE (root mean square error) to summarize model fit. R^2 represents the proportion of variation in the dependent variable that the model accounts for and RMSE is the standard deviation of residuals. A high R^2 and a lower RMSE is desirable. The models with interactions are more complicated as the coefficients cannot be directly interpreted in a meaningful substantive context. Instead, a graph has been provided that shows the predicted value at low, mean and high levels of the continuous covariate, BOS score.

Utility Value

Overall Descriptive Statistics

This summarizes the results for all students who participated in the study and completed a questionnaire at each time point.

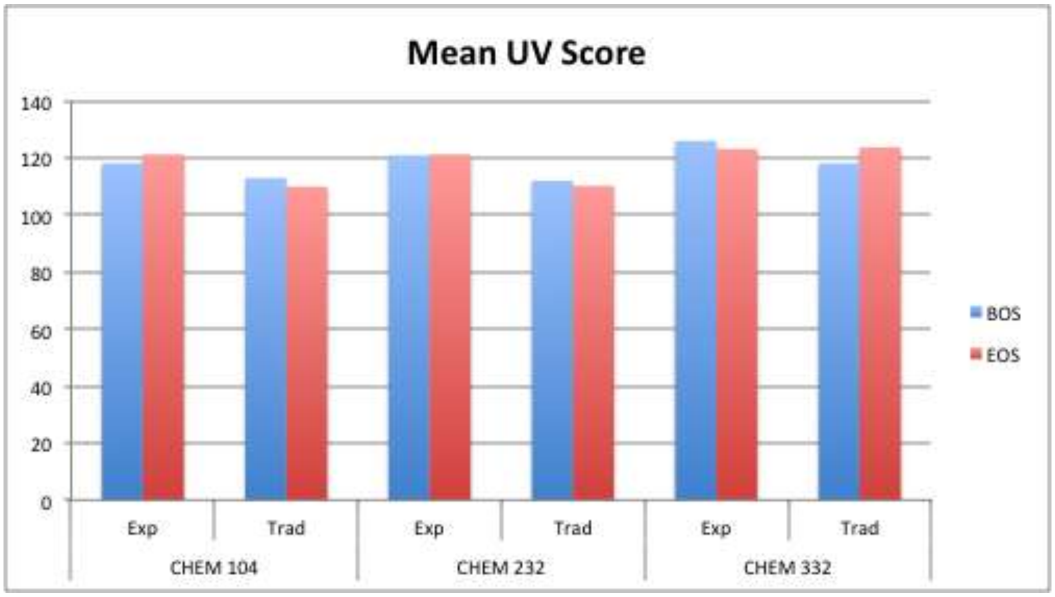
Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation
104	Experimental	BOS	128	65	154	117	16.8
		EOS	139	76	154	119	21.0
	Traditional	BOS	180	65	154	113	18.3
		EOS	368	65	154	110	19.4
232	Experimental	BOS	68	87	154	120	17.6
		EOS	75	76	154	120	18.3
	Traditional	BOS	332	65	154	112	18.4
		EOS	331	65	154	110	19.7
332	Experimental	BOS	32	92	154	125	18.5
		EOS	41	82	154	125	20.2
	Traditional	BOS	178	72	154	117	17.8
		EOS	164	80	154	124	20.0

Sample Descriptive Statistics

This summarizes the results for all students who have both a score at beginning and end of semester and are therefore included in the ANCOVA analysis. The 95% CI of Difference shows the 95% confidence interval for the difference between BOS and EOS scores

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation	95% CI of Difference
104	Experimental	BOS	79	89	154	118	16.6	(-0.74, 6.88)
		EOS	79	76	154	121	19.5	
	Traditional	BOS	116	65	154	113	18.4	(-5.78, -0.24)
		EOS	116	65	154	110*	20.2	
232	Experimental	BOS	64	87	154	121	17.6	(-4.72, 5.38)
		EOS	64	85	154	121	17.5	
	Traditional	BOS	266	65	154	112	18.1	(-4.18, 0.50)
		EOS	266	65	154	110	20.5	
332	Experimental	BOS	29	92	154	126	19.0	(-10.69, 5.04)
		EOS	29	82	154	123	20.0	
	Traditional	BOS	137	82	154	118	17.3	(2.77, 8.39)
		EOS	137	80	154	124*	19.9	

** Difference between the EOS and BOS scaled scores for the group is statistically significant ($p<0.05$).*



Utility Value – CHEM 104

The observed difference in end of semester utility value scores for CHEM 104 **is** statistically significant (p=**0.001**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 7.49 points higher than the traditional with an effect size *f*=0.23.

Experimental: 35.08+0.72*BOS Score
Traditional: 27.58+0.72*BOS Score

Utility Value – CHEM 232

The observed difference in end of semester utility value scores for CHEM 232 **is** statistically significant (p=**0.01**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 6.41 points higher than the traditional with an effect size *f*=0.14.

Experimental: 58.01+0.52*BOS Score
Traditional: 51.60+0.52*BOS Score

Utility Value – CHEM 332

The observed difference in end of semester utility value scores for CHEM 332 is not statistically significant (p=0.09) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 5.68 points **lower** than the traditional. This difference is not statistically significant with power (1- β error probability)=0.39.

Experimental: 41.26 +0.65*BOS Score
Traditional: 46.94+0.65*BOS Score

Interest Questionnaire Subscale 1

Interest Questionnaire Items 1, 2, 4-6

1. I enjoy learning about chemistry even when it is very difficult.
2. When I'm working on something in chemistry that I think is interesting, I continue working even when it takes a lot of time.
4. I always learn more about chemistry on my own if I find it interesting.
5. Knowing about chemistry is extremely valuable to me.
6. I think everyone should know a lot about chemistry.

Overall Descriptive Statistics

This summarizes the results for all students who participated in the study and completed a questionnaire at each time point.

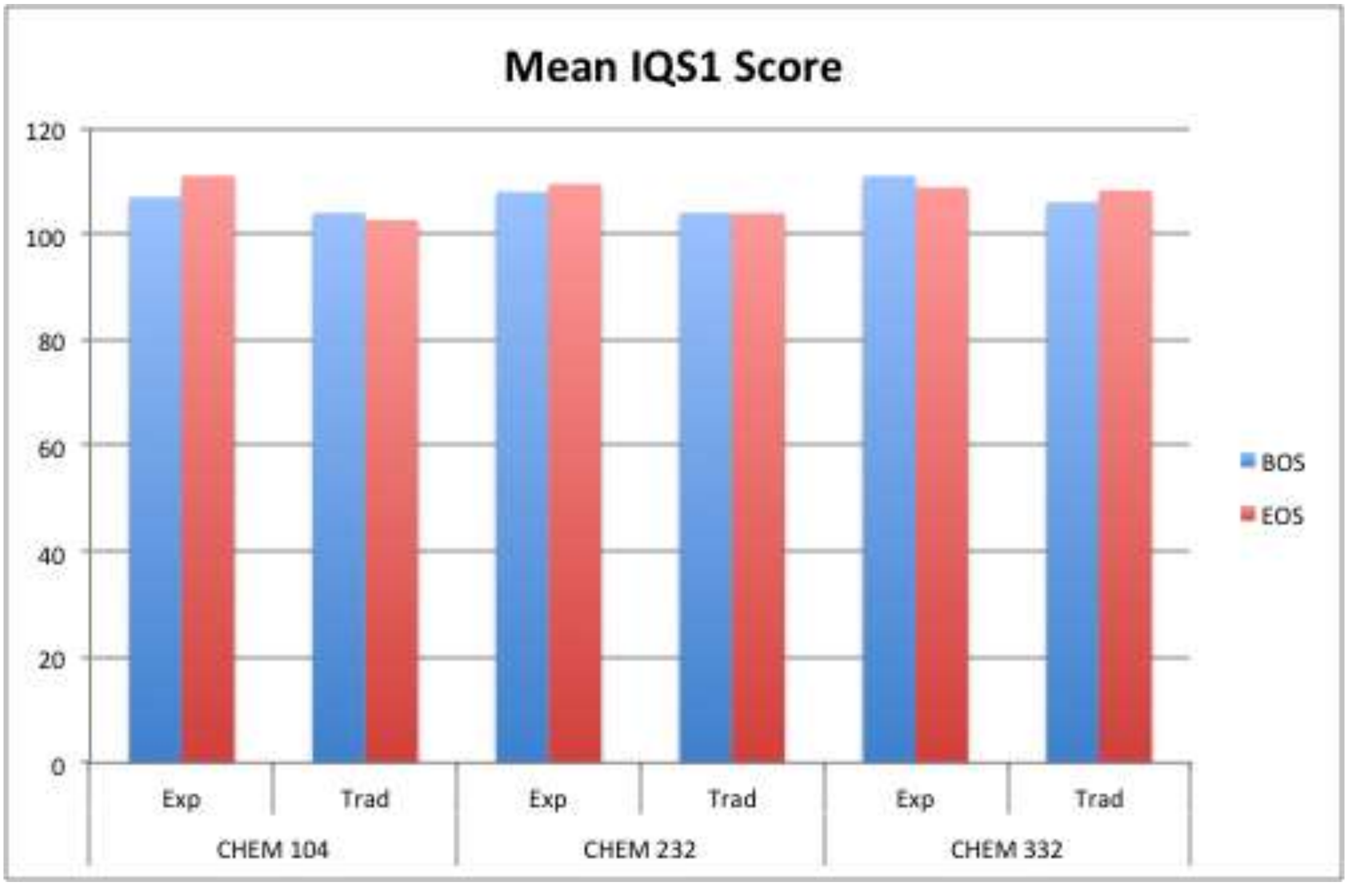
Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation
104	Experimental	BOS	128	91	143	107	8.7
		EOS	139	68	143	108	13.6
	Traditional	BOS	180	68	143	103	9.6
		EOS	368	68	143	102	10.5
232	Experimental	BOS	68	95	143	108	8.7
		EOS	75	95	143	109	10.1
	Traditional	BOS	332	68	143	104	9.6
		EOS	331	75	143	104	10.3
332	Experimental	BOS	32	95	143	111	11.7
		EOS	41	97	143	110	9.5
	Traditional	BOS	178	88	143	106	9.3
		EOS	164	83	143	109	11.9

Sample Descriptive Statistics

This summarizes the results for all students who have both a score at beginning and end of semester and are therefore included in the ANCOVA analysis. The 95% CI of Difference shows the 95% confidence interval for the difference between BOS and EOS scores.

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation	95% CI of Difference
104	Experimental	BOS	79	91	127	107	8.2	(1.58, 6.52)
		EOS	79	75	143	111*	14.0	
	Traditional	BOS	116	68	143	104	9.9	(-2.08, 0.39)
		EOS	116	68	143	103	10.8	
232	Experimental	BOS	64	95	143	108	8.6	(-1.18, 5.38)
		EOS	64	96	143	109	10.2	
	Traditional	BOS	266	68	143	104	9.2	(-0.86, 1.13)
		EOS	266	75	143	104	11.0	
332	Experimental	BOS	29	95	143	111	12.2	(-5.50, 0.95)
		EOS	29	97	127	109	8.4	
	Traditional	BOS	137	88	143	106	8.8	(0.61, 3.35)
		EOS	137	83	143	108*	11.8	

** Difference between the EOS and BOS scaled scores for the group is statistically significant ($p<0.05$).*



IQS1 – CHEM 104

The observed difference in end of semester interest questionnaire subscale 1 scores for CHEM 104 **is** statistically significant (p<**0.001**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 5.16 points higher than the traditional with an effect size *f*=0.29.

Experimental: 12.22+0.92 *BOS Score
Traditional: 7.05+0.92*BOS Score

IQS1 – CHEM 232

The observed difference in end of semester interest questionnaire subscale 1 scores for CHEM 232 is not statistically significant (p=0.08) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 2.02 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.42.

Experimental: 25.45+0.78 *BOS Score
Traditional: 23.42+0.78*BOS Score

IQS1 – CHEM 332

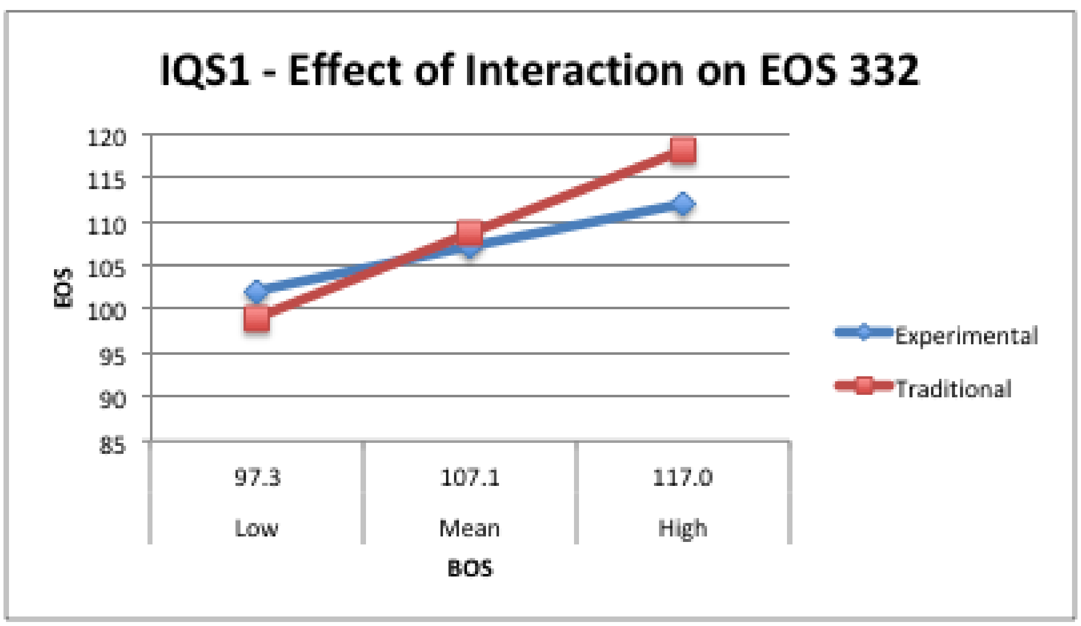
The observed difference in end of semester interest questionnaire subscale 1 scores for CHEM 332 **is** statistically significant (p=**0.04**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 3.47 points **lower** than the traditional with an effect size *f*=0.16. This model has R^2=0.49 and RMSE=8.06.

Experimental: 15.58+0.84 *BOS Score
Traditional: 19.05+0.84*BOS Score

IQS1 – CHEM 332 with Interaction

The effect of the interaction between group membership and beginning of semester scores on end of semester interest questionnaire subscale 1 scores for CHEM 332 **is** statistically significant (p=**0.001**) The estimated regression equations below indicate that for every 1 unit increase in beginning of semester scores, end of semester scores for the experimental group increase by 0.48 less than traditional. This difference is statistically significant with an effect size *f*=0.26. This model has R^2=0.53 and RMSE=7.81. The main effect of group remains significant (p=**0.002**).

The graph below shows the EOS score by group at three levels, the overall BOS mean (107.1) for all students in the sample (those that have both BOS and EOS scores) plus (117.0) or minus (97.3) the standard deviation to represent mean, high, and low scores. This demonstrates that for students with low or mean levels of BOS score there is relatively little difference between EOS score for either group. However, at high levels. the traditional group EOS scores are on average higher than experimental.



Experimental: 53.43+0.50*BOS Score
Traditional: 4.63+0.97*BOS Score

Interest Questionnaire Subscale 2

Interest Questionnaire Items 9-12

9. I know way more about chemistry than other kids I know.
10. I know a lot about the chemistry topics that I find interesting.
11. Compared to other students at my school, I am better at doing chemistry work.
12. When chemistry interests me, I am confident that I can learn about it extremely easily.

Overall Descriptive Statistics

This summarizes the results for all students who participated in the study and completed a questionnaire at each time point.

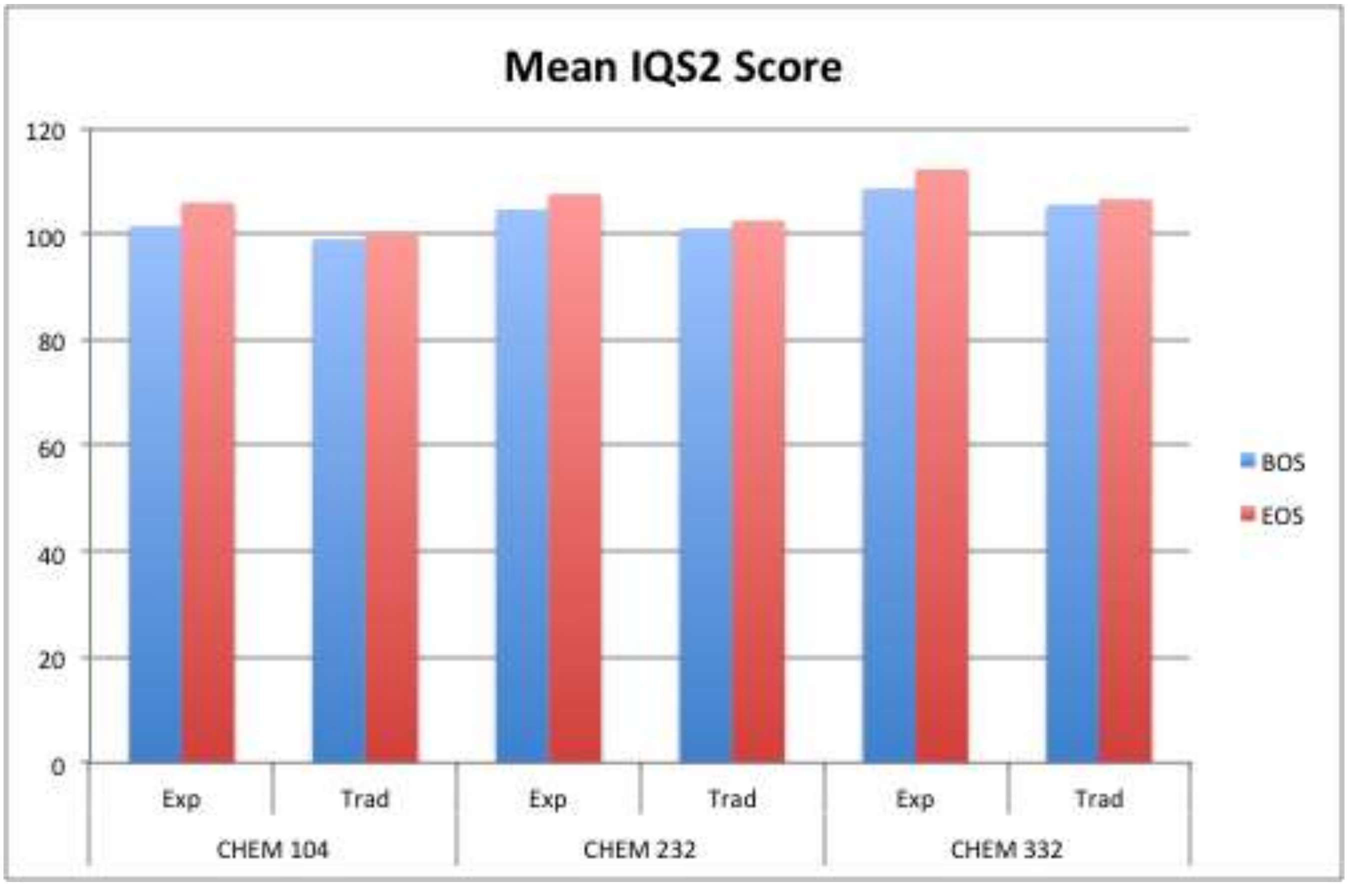
Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation
104	Experimental	BOS	128	77	140	102	10.5
		EOS	139	71	140	104	11.8
	Traditional	BOS	180	71	140	99	10.1
		EOS	368	71	140	100	12.0
232	Experimental	BOS	68	87	140	104	9.5
		EOS	75	77	140	107	13.3
	Traditional	BOS	332	71	140	101	11.3
		EOS	331	71	140	102	12.2
332	Experimental	BOS	32	81	140	109	12.7
		EOS	41	87	140	112	13.9
	Traditional	BOS	178	71	140	105	10.1
		EOS	164	71	140	107	11.9

Sample Descriptive Statistics

This summarizes the results for all students who have both a score at beginning and end of semester and are therefore included in the ANCOVA analysis. The 95% CI of Difference shows the 95% confidence interval for the difference between BOS and EOS scores.

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation	95% CI of Difference
104	Experimental	BOS	79	77	140	102	10.4	(2.14, 6.72)
		EOS	79	81	140	106*	11.4	
	Traditional	BOS	116	71	140	99	9.6	(-0.57, 2.67)
		EOS	116	71	140	100	12.4	
232	Experimental	BOS	64	89	140	105	9.5	(0.08, 5.79)
		EOS	64	84	140	108*	12.7	
	Traditional	BOS	266	71	131	101	10.7	(0.20, 2.67)
		EOS	266	71	140	103*	12.7	
332	Experimental	BOS	29	81	140	109	13.2	(0.02, 7.23)
		EOS	29	87	140	112*	14.7	
	Traditional	BOS	137	71	140	106	10.5	(-0.54, 2.63)
		EOS	137	71	140	107	12.3	

** Difference between the EOS and BOS scaled scores for the group is statistically significant ($p<0.05$).*



IQS2 – CHEM 104

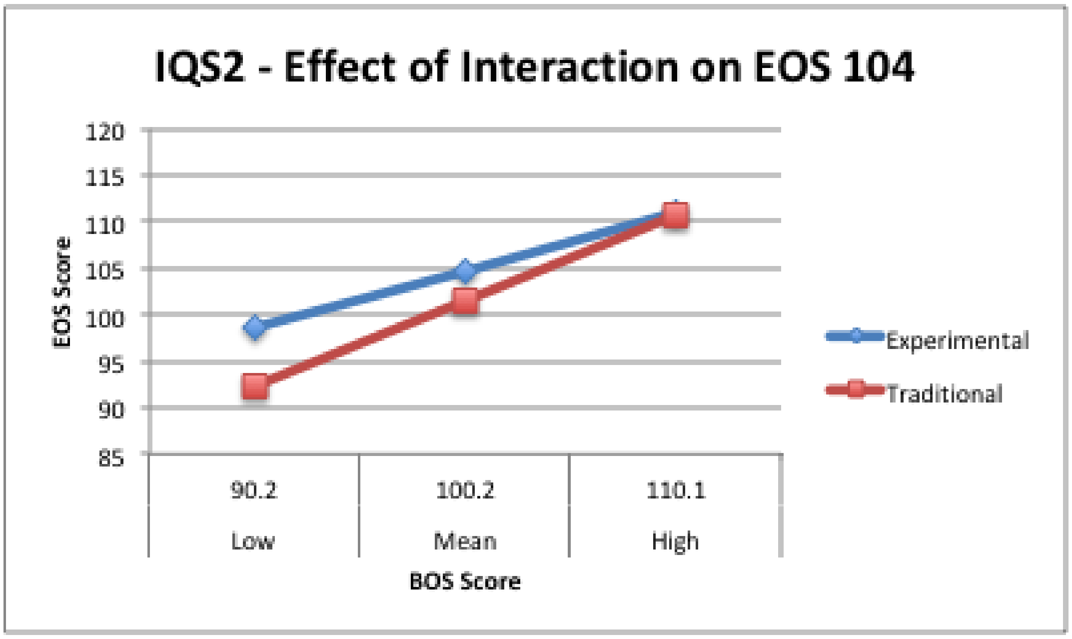
The observed difference in end of semester interest questionnaire subscale 2 scores for CHEM 104 was statistically significant (p=**0.004**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 3.91 points higher than the traditional with an effect size *f*=0.21. This model has R^2=0.45 and RMSE=9.18.

Experimental: 26.01+0.79 *BOS Score
Traditional: 22.10+0.79*BOS Score

IQS2 – CHEM 104 with Interaction

The effect of the interaction between group membership and beginning of semester scores on end of semester interest questionnaire subscale 2 scores for CHEM 104 **is** statistically significant (p=**0.03**) The estimated regression equations below indicates that for every 1 unit increase in beginning of semester scores, end of semester scores for the experimental group increase by 0.29 less than traditional. This difference is statistically significant with an effect size *f*=0.12. This model has R^2=0.46 and RMSE=9.09. The main effect of group remains significant (p=**0.01**).

The graph below shows the EOS score by group at three levels, the overall BOS mean (100.2) for students in the sample (those that have both BOS and EOS scores) and plus (110.1) or minus (90.2) the standard deviation to represent middle, high, and low scores. This demonstrates that for students with low BOS scores the intervention is more impactful and there is a larger difference between experimental and traditional scores while for students with high BOS scores, EOS scores for these groups are nearly identical.



Experimental: 42.55+0.62*BOS Score
Traditional: 9.29+0.92*BOS Score

IQS2 – CHEM 232

The observed difference in end of semester interest questionnaire subscale 2 scores for CHEM 232 is not statistically significant (p=0.09) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 2.43 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.40.

Experimental: 30.48+0.74 *BOS Score
Traditional: 28.45+0.74*BOS Score

IQS2 – CHEM 332

The observed difference in end of semester interest questionnaire subscale 2 scores for CHEM 332 is not statistically significant (p=0.09) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 3.19 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.40.

Experimental: 25.29+0.80 *BOS Score

Traditional: 22.10+0.80*BOS Score

Interest Questionnaire Subscale 3

Interest Questionnaire Items 3, 7, 8

3. I work on chemistry projects outside of school at least once a week.
7. I think of my own chemistry projects at least once a week.
8. I'm inspired to come up with my own chemistry projects to work on when I see something in chemistry that interests me.

Overall Descriptive Statistics

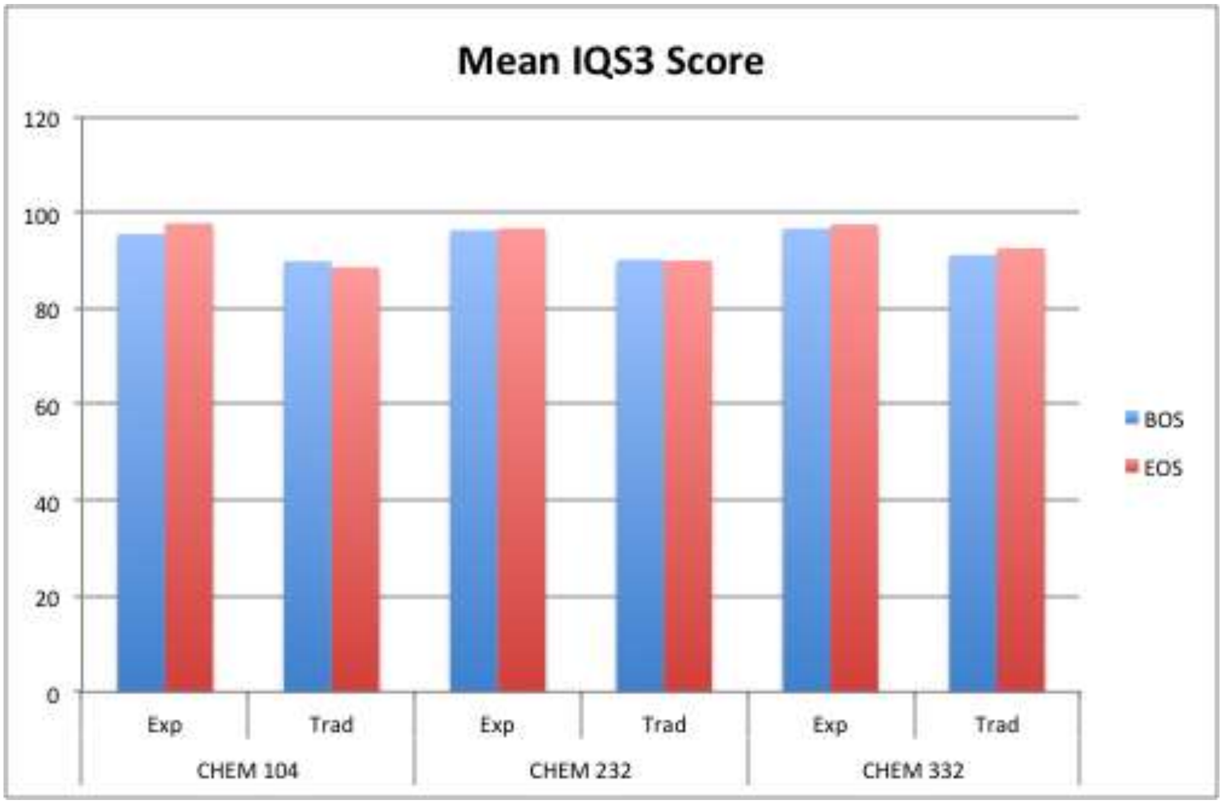
This summarizes the results for all students who participated in the study and completed a questionnaire at each time point.

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation
104	Experimental	BOS	128	67	135	96	9.2
		EOS	139	67	135	96	13.7
	Traditional	BOS	180	67	117	90	12.3
		EOS	368	67	135	88	13.2
232	Experimental	BOS	68	67	112	97	10.4
		EOS	75	67	135	96	11.6
	Traditional	BOS	332	67	135	91	12.3
		EOS	331	67	135	90	12.6
332	Experimental	BOS	32	67	117	96	10.1
		EOS	41	67	117	98	10.4
	Traditional	BOS	178	67	135	91	11.3
		EOS	164	67	135	93	13.7

Sample Descriptive Statistics

This summarizes the results for all students who have both a score at beginning and end of semester and are therefore included in the ANCOVA analysis. The 95% CI of Difference shows the 95% confidence interval for the difference between BOS and EOS scores.

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation	95% CI of Difference
104	Experimental	BOS	79	67	135	96	9.7	(-0.67, 5.15)
		EOS	79	67	135	98	13.9	
	Traditional	BOS	116	67	112	90	12.1	(-3.29, 0.79)
		EOS	116	67	117	89	13.0	
232	Experimental	BOS	64	67	112	96	10.5	(-2.25, 2.94)
		EOS	64	67	135	97	12.1	
	Traditional	BOS	266	67	117	90	11.9	(-1.50, 1.17)
		EOS	266	67	135	90	12.9	
332	Experimental	BOS	29	67	117	97	10.5	(-3.26, 4.98)
		EOS	29	67	117	98	12.0	
	Traditional	BOS	137	67	112	91	11.3	(-0.55, 3.34)
		EOS	137	67	135	93	13.4	



IQS3 – CHEM 104

The observed difference in end of semester interest questionnaire subscale 3 scores for CHEM 104 was statistically significant (p=**0.001**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 5.48 points higher than the traditional with an effect size *f*=0.23.

Experimental: 35.64 +0.65 *BOS Score
Traditional: 30.16+0.65*BOS Score

IQS3 – CHEM 232

The observed difference in end of semester interest questionnaire subscale 2 scores for CHEM 233 is not statistically significant (p=0.08) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 2.55 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.43.

Experimental: 31.80+0.67 *BOS Score
Traditional: 29.25+0.67*BOS Score

IQS3 – CHEM 332

The observed difference in end of semester interest questionnaire subscale 2 scores for CHEM 333 is not statistically significant (p=0.59) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 1.23 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.08.

Experimental: 31.89+0.68 *BOS Score

Traditional: 30.66+0.68*BOS Score

Full Interest Questionnaire

Overall Descriptive Statistics

This summarizes the results for all students who participated in the study and completed a questionnaire at each time point.

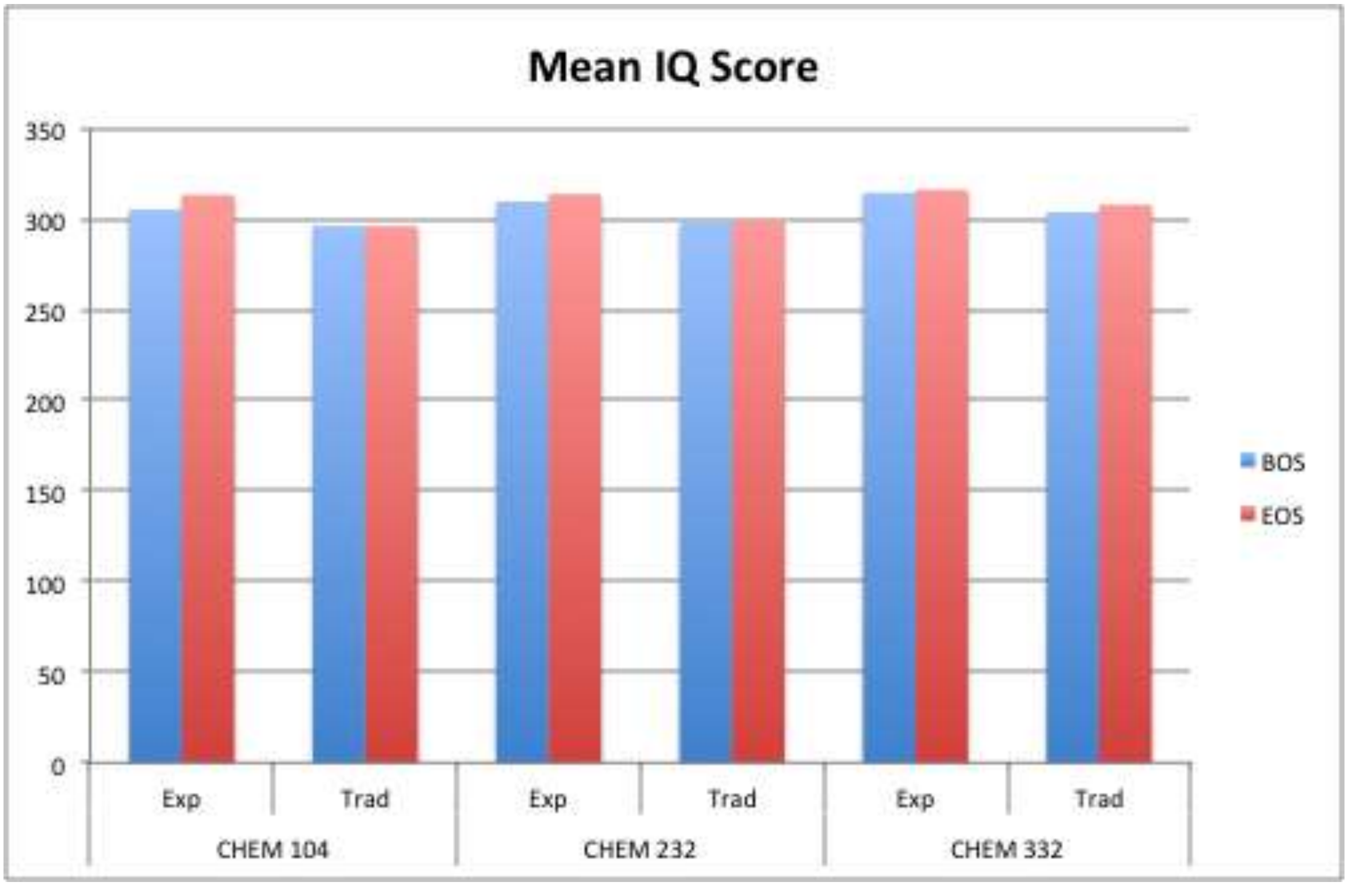
Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation
104	Experimental	BOS	128	263	375	305	17.7
		EOS	139	236	375	308	24.2
	Traditional	BOS	180	184	357	297	19.7
		EOS	368	184	445	294	23.1
232	Experimental	BOS	68	282	348	309	15.5
		EOS	75	269	445	312	25.0
	Traditional	BOS	332	245	445	299	20.3
		EOS	331	207	445	298	23.1
332	Experimental	BOS	32	279	375	314	23.5
		EOS	41	286	375	316	20.7
	Traditional	BOS	178	272	383	304	16.7
		EOS	164	265	445	308	24.6

Sample Descriptive Statistics

This summarizes the results for all students who have both a score at beginning and end of semester and are therefore included in the ANCOVA analysis. The 95% CI of Difference shows the 95% confidence interval for the difference between BOS and EOS scores.

Course	Group	BOS/EOS	N	Min	Max	Mean	Std. Deviation	95% CI of Difference
104	Experimental	BOS	79	271	375	305	17.2	(3.83, 12.57)
		EOS	79	263	375	313*	24.0	
	Traditional	BOS	116	184	353	296	19.7	(-2.98, 2.57)
		EOS	116	245	375	296	22.1	
232	Experimental	BOS	64	282	348	310	15.2	(-1.69, 9.78)
		EOS	64	279	445	314	25.6	
	Traditional	BOS	266	245	375	298	17.3	(-1.53, 3.19)
		EOS	266	207	445	299	24.9	
332	Experimental	BOS	29	279	375	314	24.6	(-3.36, 6.60)
		EOS	29	286	353	316	21.3	
	Traditional	BOS	137	272	368	304	15.6	(0.57, 7.44)
		EOS	137	265	445	308*	25.4	

** Difference between EOS and BOS scaled scores for group is statistically significant (p<0.05).*



Full IQ – CHEM 104

The observed difference in end of semester interest questionnaire scores for CHEM 104 was statistically significant (p<**0.001**). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 9.88 points higher than the traditional with an effect size *f*=0.28.

Experimental:58.76 +0.83 *BOS Score
Traditional: 48.88+0.83*BOS Score

Full IQ – CHEM 232

The observed difference in end of semester interest questionnaire scores for CHEM 233 is not statistically significant (p=0.11) The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 4.60 points higher than the traditional. This difference is not statistically significant with power (1- β error probability)=0.35.

Experimental: 41.91+0.87*BOS Score
Traditional: 37.32+0.87*BOS Score

Full IQ – CHEM 332

The observed difference in end of semester interest questionnaire scores for CHEM 333 is not statistically significant (p=0.76). The estimated regression equations below indicate that when controlling for score at the beginning of the semester students who participated in the experimental course scored an average of 1.21 points **lower** than the traditional. This difference is not statistically significant with power (1- β error probability)=0.06.

Experimental: 36.10+0.89*BOS Score
Traditional: 37.32+0.89*BOS Score

References

Cohen, J. (1969). *Statistical power analysis for the behavioural sciences.* New York: Academic Press.

Focus Group Discussion Guide

Welcome & Introduction
Thank you for volunteering to take part in this group exit interview. My name is _____, and this [assistant] is _____. We are from [UIUC department] and, like you, have been involved in the "Molecular Sciences Made Personal" research study since its beginning. As you know, you were in the experimental sections of your chemistry courses. Maybe you know some of the students who were in the control sections. You have been asked to participate in this group exit interview so that you can share your experiences in college after completing biochemistry that may have been influenced by the Molecular Sciences Made Personal chemistry courses. We appreciate your time! [Assistant's name] will be taking notes during our discussion, but sometimes during a focus group, there's a lot of conversation and it's hard to write down all the excellent points that are made! *May I voice record the discussion to facilitate our recollection?*

Privacy
I would like to reiterate the privacy rules that were outlined in your Group Exit Interview Consent Form:

- Your privacy will be protected.
- Your name will not be used in any report that is published. Nothing you say will be tied back to you.
- We are going to keep this discussion strictly confidential, and we ask that you keep what is said here, during this discussion, confidential too.

The tapes will be kept safely in a locked facility until the end of our research study, and then they will be destroyed.

Ground Rules
Let's go over some ground rules for this focus group.

1. There are no right or wrong answers. We are interested in your honest opinions and your personal experience.
2. Only one person should speak at a time. Please wait until others are finished speaking before you add to the conversation.
3. We value your input! Please contribute to the conversation as much as possible. Our goal is to learn what impact, if any, the "personalized learning" curriculum had on your courses, research, or other professional development. It is important that we hear all your perspectives on the topics discussed.
4. That said, if there are any questions you do not wish to answer or any discussions you do not wish to participate in, you do not have to do so.

Does anyone have any questions before we begin the discussion?

So we can know who's in the room, please tell us your first name, your year (e.g., junior, senior), and your major.

REMINDERS:

- There are no right or wrong answers. We are interested in your honest opinions and your personal experience.
- We value your input! Our goal is to learn what impact, if any, the "personalized learning" curriculum had on you, especially in terms of preparing you for other courses, research, or other professional development.
- If there are any questions you do not wish to answer, you may skip them.

QUESTIONS:

Influence in Classes

- Are there any classes where you feel that your performance was improved by your participation in the Molecular Sciences Made Personal intervention sections?
- Are there any classes where you feel that your performance was diminished by your participation in the Molecular Sciences Made Personal intervention sections?
- Did the Molecular Sciences Made Personal intervention sections influence your perspective or interest in any of your classes?

Benefits in Research Activities

- Are there any research activities where you feel that your performance was improved by your participation in the Molecular Sciences Made Personal intervention sections?
- Are there any research activities where you feel that your performance was improved by your participation in the Molecular Sciences Made Personal intervention sections?
- Did the Molecular Sciences Made Personal intervention sections influence your perspective or interest in any of your research activities?

WRAP-UP:

- Are there any other ways in which you believe the Molecular Sciences Made Personal intervention sections influenced you?
- Is there anything else you want to tell us about the "Molecular Sciences Made Personal" research study and your learning experiences?

PERSONAL EMAIL REQUEST FOR FUTURE CONTACT:

- We would like to request your personal email address so that we may contact you in the future to inquire if the Molecular Sciences Made Personal study has any influence on your professional development after graduation. If you choose to share your email address, please write it down on our Future Contact Email List.

Conclusion

Thank you for participating!! We appreciate that you have taken time out of your busy schedule to participate in our focus group. If you have any questions or comments, please feel free to email either of us at any time.

Diana Steele dmsteele@illinois.edu
Jose Zavala jzavala3@illinois.edu

Pharmacogenomics Project Rubric

What is the project?

This project is a chance for you to see how the chemistry we're learning in this class relates to the biochemistry taking place inside the body. To make this information more relevant to you, we're giving you the opportunity to be genotyped, so you can take the lessons learned from this project to see how your body will interact to the outside world due to your genome. Questions we could start to answer:

-Can I get norovirus?
-Would I be able to tolerate cisplatin chemotherapy?
-Would a specific drug work for me to treat a given disease (such as hepatitis C)?
-Will morphine offer pain relief to me? Why is this?

How will this project work?

This will be a group project. You will be assigned to a group of four students, all from your discussion section, to work on the project together. You will have both individual assignments (just for you) and group assignments (for the group as a whole to turn in). The individual assignments will be assigned and graded in ACE Organic. The group submissions will be assigned and turned in using Box. You will get more information about the assignments as we start the project.

At the end of the project, you will create a poster that summarizes your work. Our last two days of class will be a poster session where all groups will get an opportunity to present their work to classmates, U of I faculty and administration, and scientists from outside the Illinois community (Last year we invited a Nobel Laureate!)

How will you earn your grade for the project?

The project will account for 100 points of your overall class grade. Points will be earned as follows:

Individual Assignments found in ACE Organic (7 x 5 points)	35 points
Group Assignments found in the group Box account (7 x 5 points)	35 points
Final poster and poster presentation	30 points
	100 points

Tentative Due Dates:

Exercise 1 – Pathway Analysis & Genetic Variation	February 9
Exercise 2 – Molecules in Binding Pocket	February 24
Exercise 3 – Chemistry at Site of Variation	March 3
Exercise 4 – 3D Model	March 9
Exercise 5 – Reaction of Interest	April 7
Exercise 6 – Title and Combine Exercises	April 13
Exercise 7 – Final Poster Submittal	April 20

Where can you go for assistance?

A current Chemistry 332 student will work with your group as a mentor. Your mentor will NOT complete the project for you; you are expected to do your own work. Your mentor WILL provide advice and clarify aspects of the project that are unclear to you.
Additionally, there will be regular office hours where you may go for assistance with your project. MEG and Blake will be in the Wohlers Computer Lab on Monday to Thursday from 7-9pm.

Pharmacogenomics Project Sample Prompts

Exercise #1 Instructions

Goal - submit the Genetic Variation Panel with the following information!!

Let's begin getting information for the *Genetic Variation* panel (see Figure). **For this ACE problem you are to submit three pieces of information:**

1. Your group's assigned rsID
2. Your group's assigned chemical
3. The name of the gene associated with your rsID.

This problem asks you to submit the PharmGKB annotation text that's associated with your group's rsID and chemical. This is the text in the gray box in the Genetic Variation panel (see Fig. 1). In order to obtain this text, you'll need to register an account on the PharmGKB website (it's free). Take 5 minutes and register now, being sure to record your User ID and password. As the example shows (Fig. 1 - Fig. 3), the annotation text reported is that specific for Emma Borhanian's genotype (C_T in this particular example). You and your group are also expected to report the annotation text specific to Emma's Genotype. In the event that there is no data for Emma Borhanian at this rsID, report the annotation text for the heterozygote genotype. Use GenomeBrowse to locate the PharmGKB annotation text. Click on the variant in the PharmGKB_Variants track (like this) and look in the console for the hyperlinked rsID. Click on the hyperlink. If you are not signed into the PharmGKB page, you will see annotation records that look like Fig. 2. Once you register and sign in, you'll see the full details for this rsID (Fig. 3). Find all of the annotations with your group's chemical at this rsID (there's at least one, possibly more). **Submit as your answer the PharmGKB annotation text associated with Emma Borhanian's genotype and the rsID / chemical assigned to your group.**

In this problem you are to explain how the inter-individual variability in drug response arises from individual's genetic differences. Examples of these synopses and their pathway diagram are shown in Figs. 1 and 2. Theses synopses are to follow a script as explained below, and must have fewer than 125 words. The information for the synopsis will come from research that you will gather from these resources:

wikipedia
PharmGKB
DrugBank
UniProt

Write your synopsis with strict adherence to the following script. The script below is written as a color-coded "recipe" so you can easily relate these instructions to the text in the examples below.

Begin with one sentence that gives a broad overview of the disease, the therapy and the:

- drug's metabolism (e.g., if your group is studying a metabolizing enzyme variant, see EXAMPLE 1)

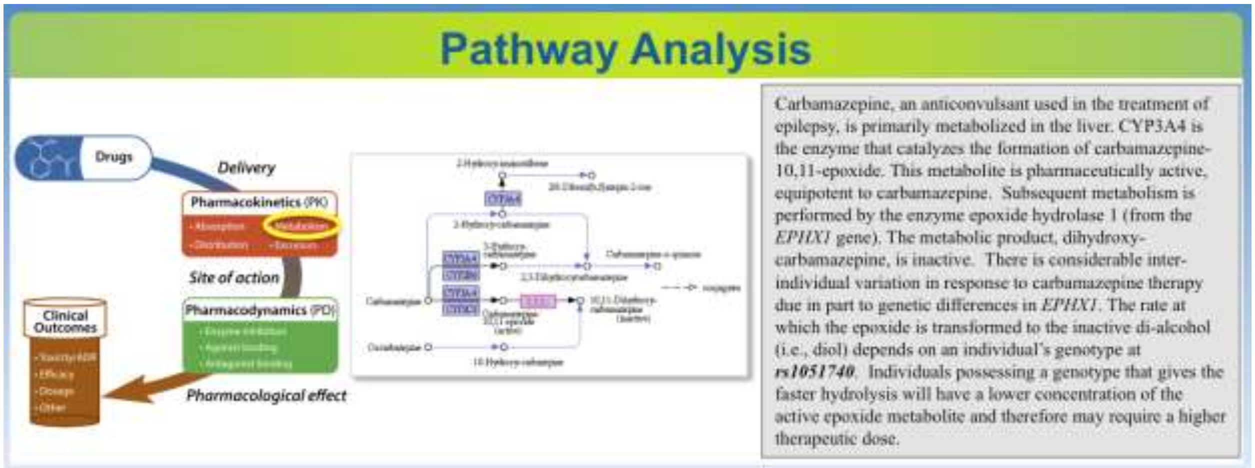
- physiological system targeted by the drug (e.g., if your group is studying a pharmacodynamic variant, see EXAMPLE 2)
- organ and membrane barrier that impedes mass transfer (e.g., if your group is studying a transporter variant)
- Next, write one to three sentences to explain how your drug relates to your biochemical pathway.
- Write one or two sentences that identifies the gene responsible for inter-individual drug response variability.
- Write one sentence that indicates a rate difference, affinity difference, or receptor concentration difference etc. as resulting from a variation at the rsID being investigated.
- Write one sentence to explain the consequences: i.e., relate the genotype variations to the differences in the reaction rate, affinity, or receptor concentration.

EXAMPLE 1 (see Fig. 1)
Carbamazepine, an anticonvulsant used in the treatment of epilepsy, is primarily metabolized in the liver. CYP3A4 is the enzyme that catalyzes the formation of carbamazepine-10,11-epoxide. This metabolite is pharmaceutically active, equipotent to carbamazepine as an anticonvulsant. Subsequent metabolism is performed by the enzyme epoxide hydrolase 1 (from the *EPHX1* gene). The metabolic product, 10,11-dihydroxycarbamazepine, is inactive. There is considerable inter-individual variation in response to carbamazepine therapy due in part to genetic differences in the *EPHX1* gene. The rate at which the active epoxide is transformed to the inactive di-alcohol (i.e., diol) depends on an individual's genotype at rs1051740. Individuals possessing a genotype that gives the faster hydrolysis will have a lower concentration of the active epoxide metabolite and therefore may require a higher therapeutic dose.

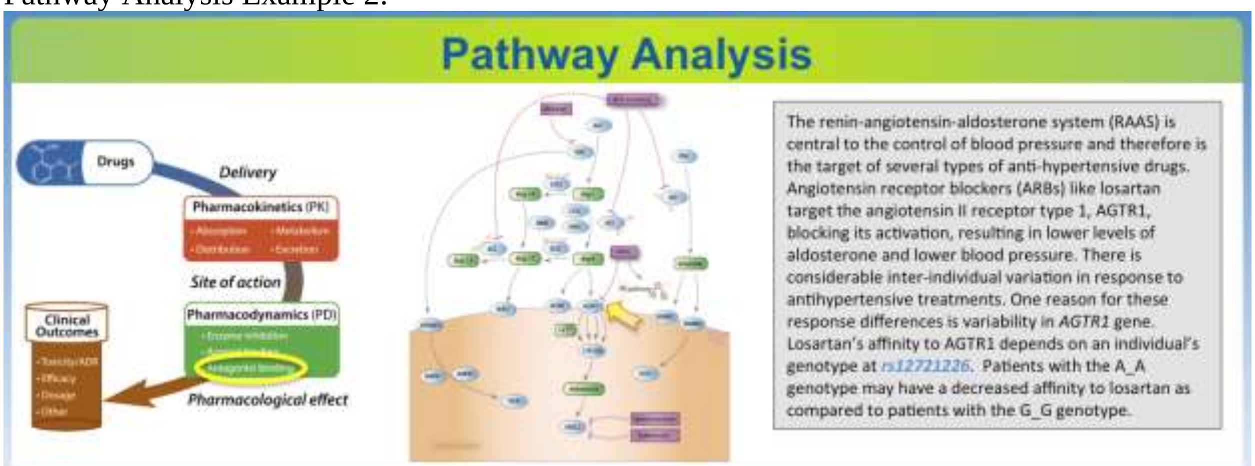
EXAMPLE 2 (see Fig. 2)
The renin-angiotensin-aldosterone system (RAAS) is central to the control of blood pressure and therefore is the target of several types of anti-hypertensive drugs. Angiotensin receptor blockers (ARBs) like losartan target the angiotensin II receptor type 1, *AGTR1*, blocking its activation, resulting in lower levels of aldosterone and lower blood pressure. There is considerable inter-individual variation in response to antihypertensive treatments. One reason for these response differences is variability in the *AGTR1* gene. Losartan's affinity to *AGTR1* depends on an individual's genotype at rs12721226. Patients with the A_A genotype may have a decreased affinity to losartan as compared to patients with the G_G genotype.

Now do the research to gather the necessary information and write your synopsis.

Pathway Analysis Example 1:



Pathway Analysis Example 2:



The Journal Entry assignment prompts described in Chapter 02 can be seen below. They are accompanied by the Journal Rubric from Fall 2019 and samples of excellent student responses to these prompts.

Nutrigenomic Journal Rubric

Each journal entry is worth 10 points of your final course grade. You will earn the full 1% credit by completing the following checklist for each journal entry.

Legibility of the journal entry: 2 points

- Is your journal completely legible?
  - +2 points
- Is your journal impossible to read?
  - Edit your journal entry and resubmit. You will get no credit until it is legible.

Academic rigor: 2 points

- Does it look like you spent time and effort to make a quality journal entry?
  - +2 points

Clearly answering the prompt: 3 points

- Are your answers to the prompt easily identified?
  - +1 point
- Are your answers to the prompt correct?
  - +2 points

Artistic expression: 3 points

- Does it look aesthetically pleasing? (you don't have to be a great artist, but you do have to try!)
  - +1 point
- Did you effectively use drawings/figures that connect with your text?
  - +2 points

If your journal is legible, rigorous, correct, and artistic, then you get a full 10 points!

Nutrigenomic Journal Sample Prompts

Prompt: Billy's Carbohydrates

Due date:
This journal entry is due Sunday, September 29 at 23:59

Context:
Billy Ashcraft has come to your office asking for dietary advice. He has sought you out as a primary healthcare physician based on your reputation for genuinely caring about your patients, and getting to know them on a personal level and providing clear & concise advice. During the visit, he tells you that he is a first year graduate student at a nearby university. Billy confesses that he has been having trouble staying awake through his coursework, research, and daily activities so he often drinks energy drinks to keep going.

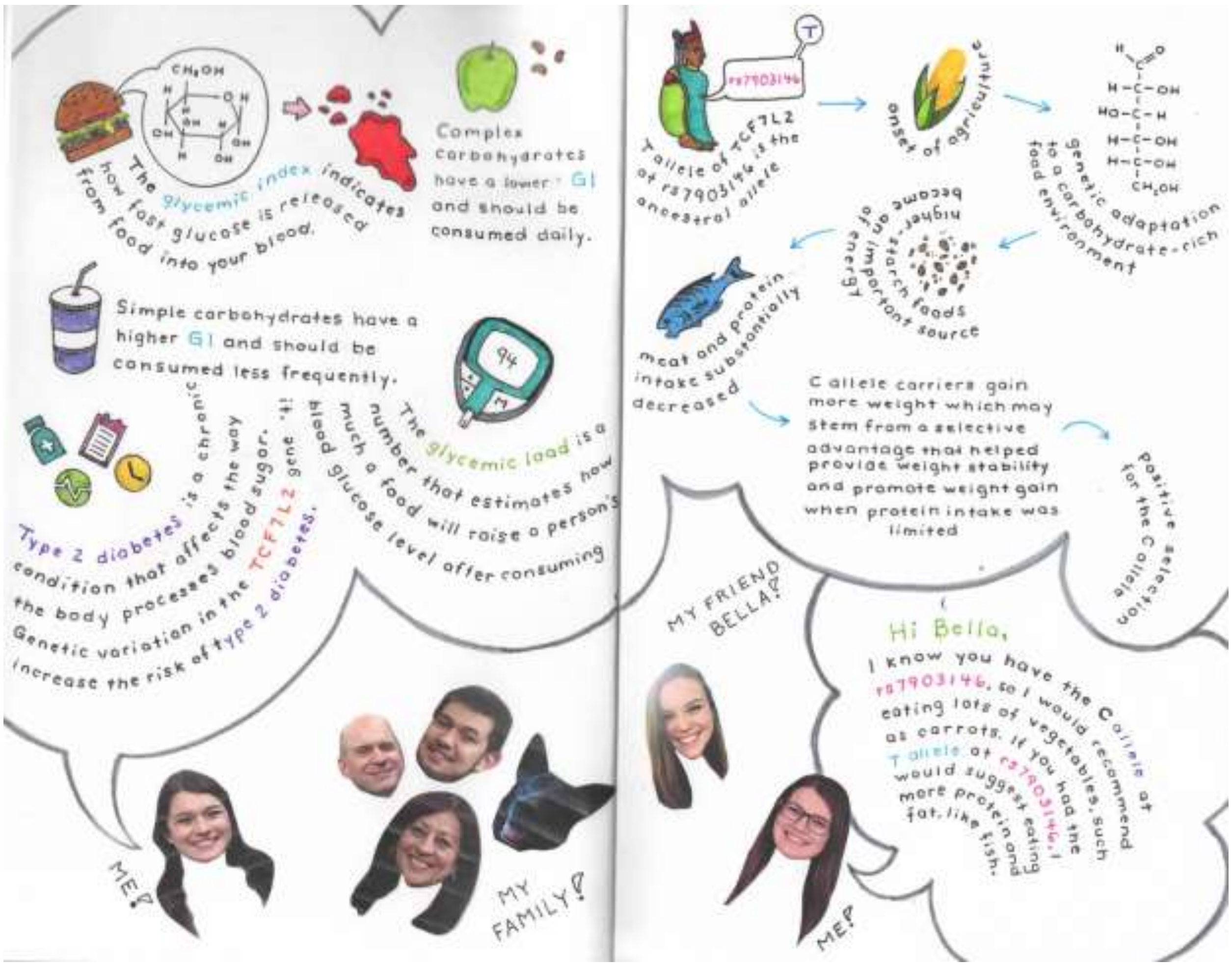
Prompt:
As Billy's physician, you will advise Billy on how to live a healthier life by eating a healthier diet. **Craft an artistic journal entry** to answer the following questions for Billy:

- Record your diet for 1 day (this will be Billy's typical diet, you can record for more days if you like!). How much added sugar and carbohydrates does Billy typically consume?
- Explain glycemic index, glycemic load, and how the TCF7L2 gene (see the articles below) may affect the development of type 2 diabetes.
- Billy has recently purchased a 23andMe kit and shared his genetic information with your office. He as a T allele at rs7903146. He wants to know how this may affect his likelihood of developing type 2 diabetes.
- Billy wants a suggestion for a healthy snack he can take between classes to stay awake.

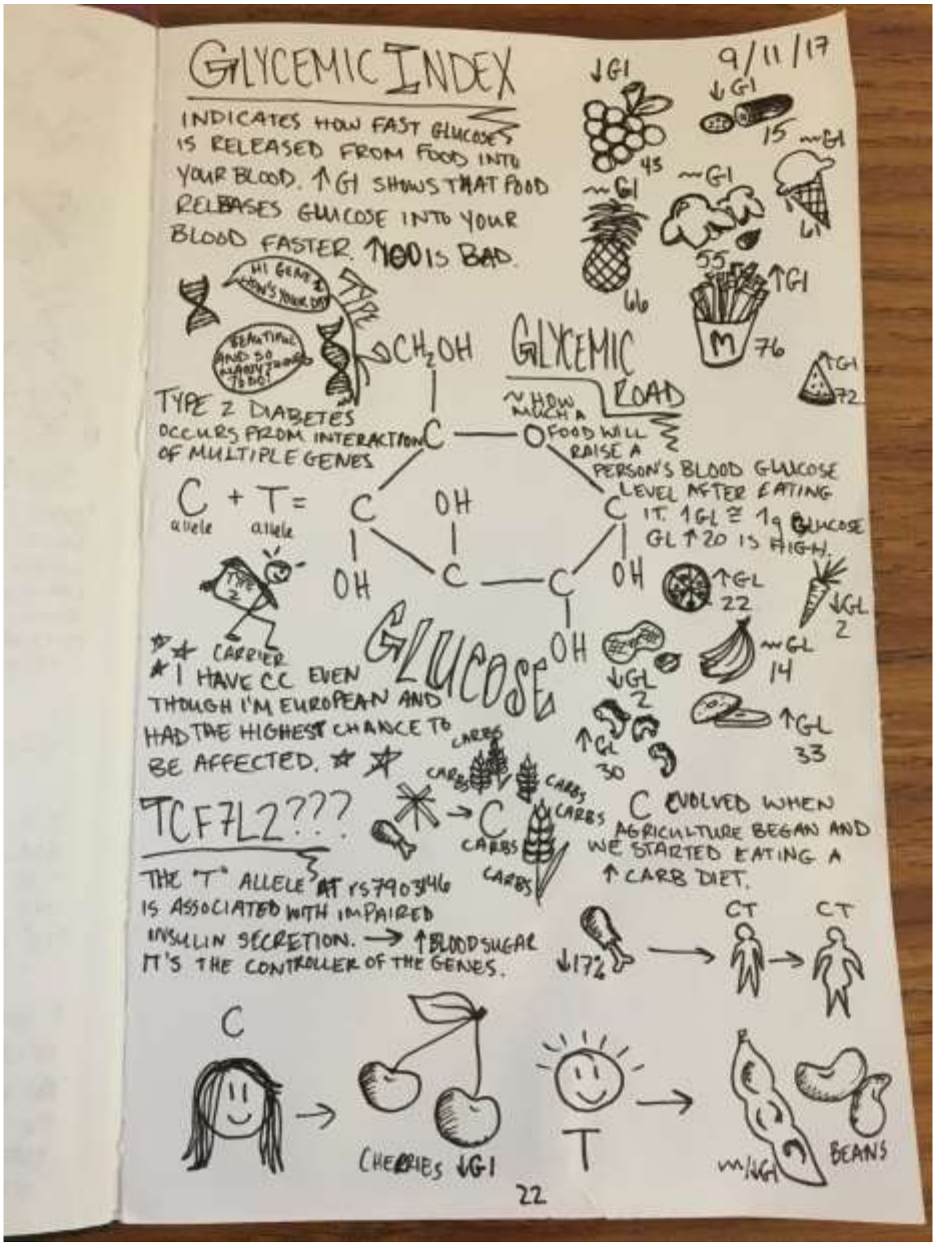
Making GBHealthwatch Account:
We want to introduce you all to GB Healthwatch. We will be using GB Healthwatch several times throughout the semester so take a moment to create your own GB Healthwatch account.

Tracking Nutrition:
After you've created your GB Healthwatch Account, track your food for 1 day (if you have a really healthy diet, try inputting a high-sugar diet and pretend it's Billy's diet!). You can retroactively add meals if you forgot to keep track for a day. After logging your meals, take a look at the amount of carbs and added sugar you have consumed. Click on "Report", then click on "view nutrition trends".

Sugar Consumption & Nutrigenomics:
Next, read this article on carbohydrates, paying special attention to the parts about glycemic index and glycemic load, and this article on type 2 diabetes and the TCF7L2 gene. This article is a little information dense, but don't worry! Read it to the best of your current ability; we'll practice reading information dense articles throughout the semester.



The glycemic index indicates how fast glucose is released from food into your blood.
Complex carbohydrates have a lower GI and should be consumed daily.
Simple carbohydrates have a higher GI and should be consumed less frequently.
94
The glycemic load is a number that estimates how much a food will raise a person's blood glucose level after consuming it.
Type 2 diabetes is a chronic condition that affects the way the body processes blood sugar. Genetic variation in the TCF7L2 gene increase the risk of type 2 diabetes.
ME!
MY FAMILY!
T
rs7903146
T allele of TCF7L2 at rs7903146 is the ancestral allele
onset of agriculture
genetic adaptation to a carbohydrate-rich food environment
higher-starch foods become an important source of energy
meat and protein intake substantially decreased
C allele carriers gain more weight which may stem from a selective advantage that helped provide weight stability and promote weight gain when protein intake was limited
positive selection for the C allele
MY FRIEND BELLA!
Hi Bella,
I know you have the C allele at rs7903146, so I would recommend eating lots of vegetables, such as carrots. If you had the T allele at rs7903146, I would suggest eating more protein and fat, like fish.
ME!


GLYCEMIC INDEX
9/11/17
INDICATES HOW FAST GLUCOSE IS RELEASED FROM FOOD INTO YOUR BLOOD. ↑GI SHOWS THAT FOOD RELEASES GLUCOSE INTO YOUR BLOOD FASTER. ↑GI IS BAD.
↓GI
↓GI
15
~GI
45
~GI
~GI
61
55
↑GI
66
76
↑GI
72
HI GENE
TYPE 2 DIABETES OCCURS FROM INTERACTION OF MULTIPLE GENES
CH_2OH
GLYCEMIC LOAD
~HOW MUCH A FOOD WILL RAISE A PERSON'S BLOOD GLUCOSE LEVEL AFTER EATING IT. 1GL ≅ 1g GLUCOSE GL ↑20 IS HIGH.
C + T =
allele allele
C
OH
C
OH
OH
C
C
OH
O
C
C
OH
GLUCOSE
↑GL 22
↓GL 2
~GL 14
↓GL 2
↑GL 33
↑GL 30
CARRIER
★ I HAVE CC EVEN THOUGH I'M EUROPEAN AND HAD THE HIGHEST CHANCE TO BE AFFECTED. ★
CARBS
TCF7L2???
C
C EVOLVED WHEN AGRICULTURE BEGAN AND WE STARTED EATING A ↑CARB DIET.
THE "T" ALLELE AT rs7903146 IS ASSOCIATED WITH IMPAIRED INSULIN SECRETION. → ↑BLOOD SUGAR
IT'S THE CONTROLLER OF THE GENES.
↓17%
CT
CT
C
CHERRIES ↓GI
T
m/↓GI
BEANS
22

Prompt: Enter Candyman

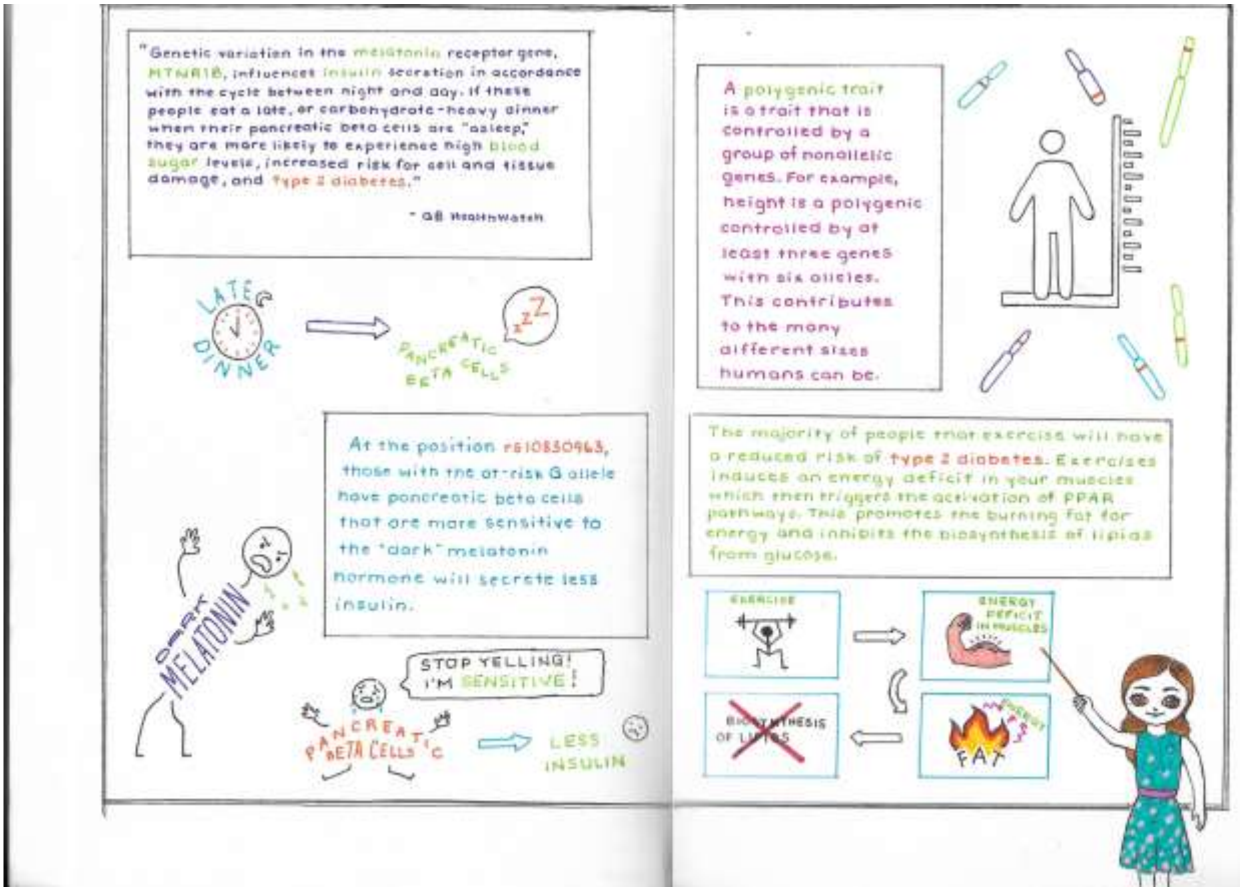
Due date:
This journal entry is due Sunday, November 3 at 23:59.

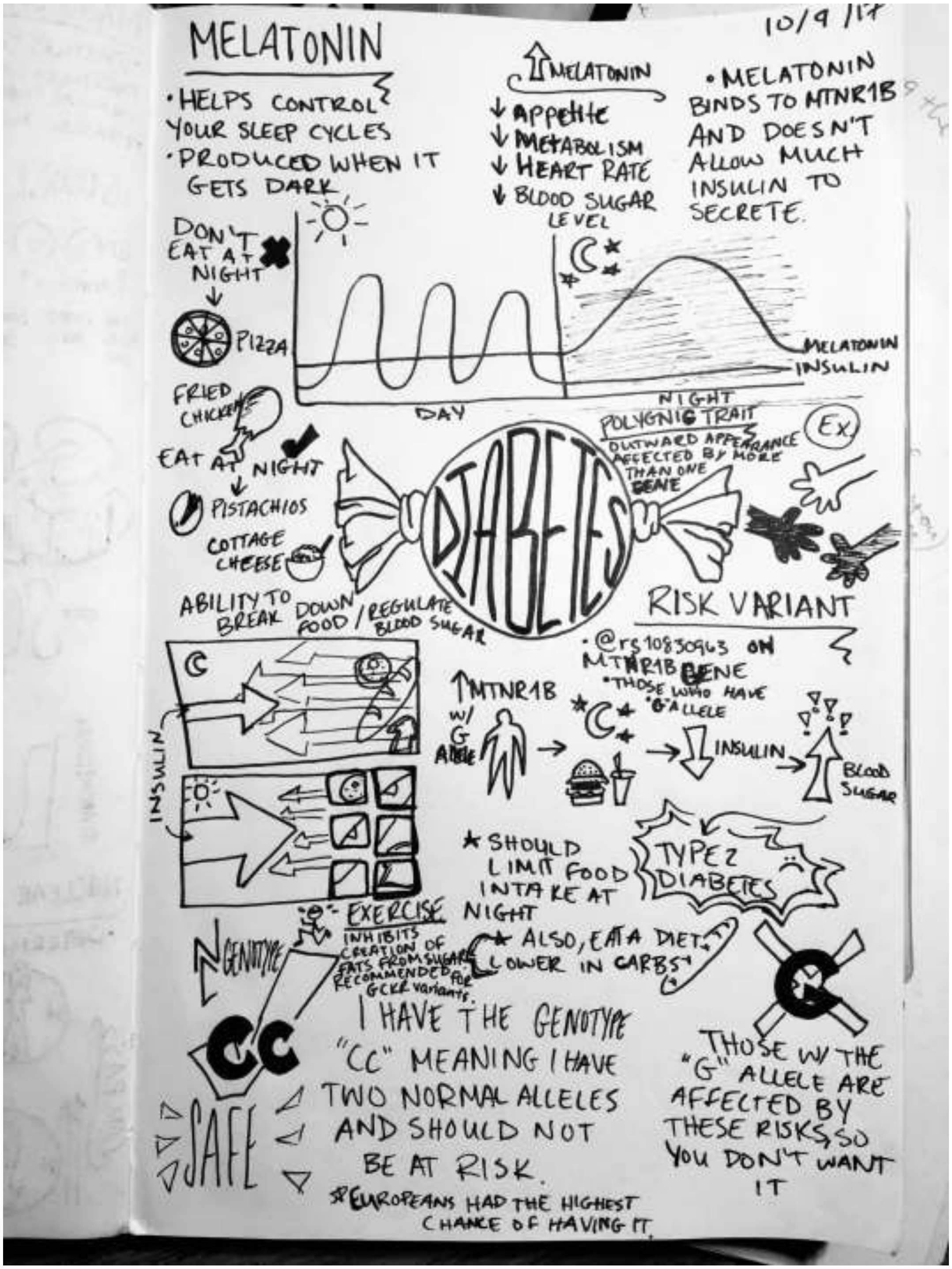
Context:
This time we'll be learning about the connection between the time we eat and the potential for developing type 2 diabetes! Billy Ashcraft has come into your doctor's office with another question!

Billy confesses that he has been too busy to prepare his own meals and has been eating a lot of fast food with his fellow graduate students - especially when he leaves the bar with his friends and they all stop to get wings and tacos before going home. Even when he doesn't go out late at night, he often eats junk food while watching Netflix before bed.

Prompt:
As Billy's physician, you will advise Billy on how to live a healthier life by eating a healthier diet. **Craft an artistic journal entry** to answer the following questions for Billy:

- Billy's Diet: **How much added sugar and carbohydrates does Billy typically consume?**
    - Record your diet for 1 day and use this as Billy's typical diet
    - OR
    - Make up an unhealthy diet and use this as Billy's typical diet
- Read this article on dinner & diabetes to get some insight into the connection between melatonin and insulin. Explain the connection between **melatonin,** the **MTNR1B receptor, insulin,** and **blood sugar.**
- According to Billy's 23andMe results, he has the risk variant at rs1080963. Explain the consequences of this risk variant to Billy.
- The importance of making healthy dietary choices before bed. Given your knowledge of glycemic index and glycemic load, **point out two poor late night snacks and recommend two healthier late night snack choices.** For example, you may recommend that Billy replace the soda/pop and chocolate bar he eats while watching Netflix before bed with water, carrots, and hummus.


"Genetic variation in the melatonin receptor gene, MTNR1B, influences insulin secretion in accordance with the cycle between night and day. If these people eat a late, or carbohydrate-heavy dinner when their pancreatic beta cells are "asleep," they are more likely to experience high blood sugar levels, increased risk for cell and tissue damage, and type 2 diabetes."
- GB HealthWatch
LATE DINNER
PANCREATIC BETA CELLS
zzZ
At the position rs10830963, those with the at-risk G allele have pancreatic beta cells that are more sensitive to the "dark" melatonin hormone will secrete less insulin.
DARK MELATONIN
STOP YELLING! I'M SENSITIVE!
PANCREATIC BETA CELLS
LESS INSULIN
A polygenic trait is a trait that is controlled by a group of nonallelic genes. For example, height is a polygenic controlled by at least three genes with six alleles. This contributes to the many different sizes humans can be.
The majority of people that exercise will have a reduced risk of type 2 diabetes. Exercises induces an energy deficit in your muscles which then triggers the activation of PPAR pathways. This promotes the burning fat for energy and inhibits the biosynthesis of lipids from glucose.
EXERCISE
ENERGY DEFICIT IN MUSCLES
FAT
BIOSYNTHESIS OF LIPIDS


MELATONIN
10/9/17
·HELPS CONTROL YOUR SLEEP CYCLES
·PRODUCED WHEN IT GETS DARK
⇑ MELATONIN
↓ APPETITE
↓ METABOLISM
↓ HEART RATE
↓ BLOOD SUGAR LEVEL
·MELATONIN BINDS TO MTNR1B AND DOESN'T ALLOW MUCH INSULIN TO SECRETE.
DON'T EAT AT NIGHT
PIZZA
FRIED CHICKEN
EAT AT NIGHT
PISTACHIOS
COTTAGE CHEESE
DAY
NIGHT
MELATONIN
INSULIN
POLYGENIC TRAIT
OUTWARD APPEARANCE AFFECTED BY MORE THAN ONE GENE
Ex
DIABETES
ABILITY TO BREAK DOWN FOOD / REGULATE BLOOD SUGAR
RISK VARIANT
·@rs10830963 ON MTNR1B GENE
·THOSE WHO HAVE "G" ALLELE
INSULIN
⇑ MTNR1B W/ G ALLELE
⇓ INSULIN
⇑ BLOOD SUGAR
★ SHOULD LIMIT FOOD INTAKE AT NIGHT
TYPE 2 DIABETES
EXERCISE
INHIBITS CREATION OF FATS FROM SUGAR. RECOMMENDED FOR GCKR variants.
★ ALSO, EAT A DIET LOWER IN CARBS
GENOTYPE
CC
SAFE
I HAVE THE GENOTYPE "CC" MEANING I HAVE TWO NORMAL ALLELES AND SHOULD NOT BE AT RISK.
★ EUROPEANS HAD THE HIGHEST CHANCE OF HAVING IT.
G
THOSE W/ THE "G" ALLELE ARE AFFECTED BY THESE RISKS, SO YOU DON'T WANT IT

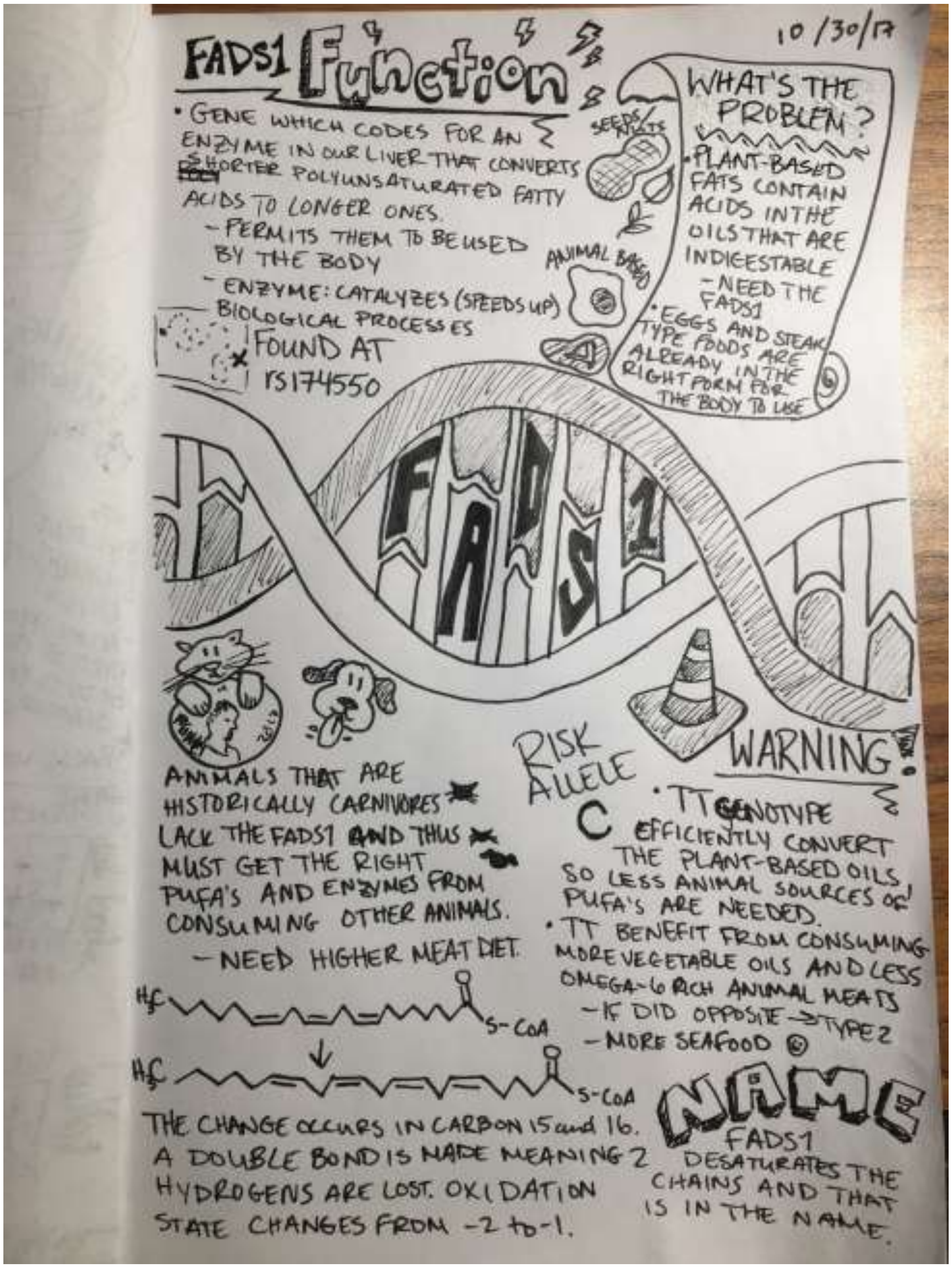
Prompt: FADS1

Due date:
This journal entry is due on **Friday, December 20 at 23:59.**

Context:
Billy Ashcraft has returned to your office concerned about his dietary fat intake. Diabetes runs in his family and he would like to know about any preventive measures he can take to reduce his risk of developing type 2 diabetes.

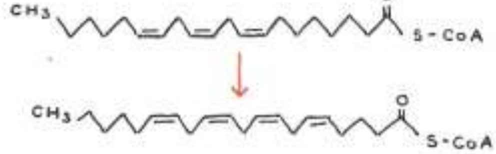
Prompt:
In this journal entry, we will use our knowledge of oxidation states, saturation, and functional groups to explain the implications of having a risk allele in FADS1 to Billy Ashcraft.

- Read this article on FADS1. Draw a figure to compare linolenic and linoleic acids against Eicosapentaenoic Acid (EPA), Docosahexaenoic Acid (DHA), and arachidonic acid. Explain the difference between
- The mechanism of FADS (https://www.sciencedirect.com/science/article/abs/pii/S0952327802002600) is a little too complicated for Billy (and it is currently outside of our scope until Orgo 2!). However, at this point you can explain to him what the structure of a FA looks like before and after being desaturated by FADS (don't worry about e- flow arrows, just draw the starting material and product of FADS). Explain the oxidation state difference between the substrate and product found in this KEGG reaction page for FADS1.
- Give Billy a dietary suggestion to balance out his omega 3 and omega 6 ratio.


10/30/17
FADS1 Function
• GENE WHICH CODES FOR AN ENZYME IN OUR LIVER THAT CONVERTS SHORTER POLYUNSATURATED FATTY ACIDS TO LONGER ONES.
- PERMITS THEM TO BE USED BY THE BODY
- ENZYME: CATALYZES (SPEEDS UP) BIOLOGICAL PROCESSES
FOUND AT rs174550
SEEDS/NUTS
ANIMAL BASED
WHAT'S THE PROBLEM?
• PLANT-BASED FATS CONTAIN ACIDS IN THE OILS THAT ARE INDIGESTABLE
- NEED THE FADS1
• EGGS AND STEAK TYPE FOODS ARE ALREADY IN THE RIGHT FORM FOR THE BODY TO USE
FADS1
ANIMALS THAT ARE HISTORICALLY CARNIVORES LACK THE FADS1 AND THUS MUST GET THE RIGHT PUFA'S AND ENZYMES FROM CONSUMING OTHER ANIMALS.
- NEED HIGHER MEAT DIET.
RISK ALLELE
C
WARNING!
• TT GENOTYPE EFFICIENTLY CONVERT THE PLANT-BASED OILS, SO LESS ANIMAL SOURCES OF PUFA'S ARE NEEDED.
• TT BENEFIT FROM CONSUMING MORE VEGETABLE OILS AND LESS OMEGA-6 RICH ANIMAL MEATS
- IF DID OPPOSITE → TYPE 2
- MORE SEAFOOD ☺
H₃C
S-CoA
NAME
FADS1 DESATURATES THE CHAINS AND THAT IS IN THE NAME.
THE CHANGE OCCURS IN CARBON 15 and 16. A DOUBLE BOND IS MADE MEANING 2 HYDROGENS ARE LOST. OXIDATION STATE CHANGES FROM -2 to -1.

The FADS1 gene encodes for an enzyme in your liver that converts shorter length PUFAs to longer biologically active forms. EPA, DHA and arachidonic acid play an important role in our health. They provide strutture for membranes, act as messengers between and within cells, and serve as ligands, or "glue" for transcription factors. These fatty acids are thrown into the center place of inflammatory conditions by these biological pathways. In addition to inflammatory conditions, metabolic disorders and diabetes can arise.

It's important to note that obligate carnivores, such as your cat Penny lack a functional FADS1 gene and must get their bioactive PUFAs from consuming other animals



This is the reaction that occurs when an FA is desaturated by FADS. Fatty Acid Desaturase is abbreviated to FADS which explains its name. Before desaturation, FA only has three double bonds in its structure, but after the reaction, the FA has four double bonds. Overall, the reaction had an oxidation state change of -2 since a double bond was gained resulting in the loss of two hydrogens which each carried a +1 charge.

Joseph, with the TT genotype at rs174550 you possess the active form of the FADS1 gene. The active form allows for adequate activity of the conversion of shorter length PUFAs to longer length active forms. If you had a variant at rs174550 you could have reduced activity of the converting enzyme.


USE?
TOO MUCH! = BAD ?
11/19/17
β CAROTENE
• FAT-SOLUBLE VITAMIN CRUCIAL FOR VISION AND HEALTHY SKIN, TEETH, SKELETAL AND SOFT TISSUES
• BECAUSE FAT SOLUBLE, ACCUMULATES IN LIVER
– DOUBLE VISION
– SKIN IRRITATION
– HAIR LOSS
– HEADACHE
– MUSCLE PAIN
– LOSS OF BALANCE
• CAN SERVE AS ANTIOXIDANTS IN THE BODY
• CAROTENES COME FROM PLANTS
• GENERALLY, RED, ORANGE, & YELLOW FRUITS AND VEGGIES HAVE MORE PRO-VITAMIN A CAROTENE
• SYMPTOM OF DEFICIENCY CAN BE NIGHT BLINDNESS – OR DRY EYES
RETANOL
• FROM ANIMAL FAT
• BIOLOGICALLY ACTIVE FORM OF VITAMIN A
• PRECURSOR FOR MAKING LIGHT SENSORS IN EYES
VITAMIN A
DEFICIENCY
MECHANISM
BCMO1 GENE
• VARIANTS MAY REQUIRE MORE VITAMIN A
– PARTICULARLY RETINOL
CODES FOR ENZYME THAT CONVERTS CAROTENES TO RETINOL
T-ALLELE CARRIERS HAVE A BCMO1 ENZYME ABOUT 60% LESS ACTIVE THAN A/C CARRIERS
– CONSUME MORE ANIMAL SOURCE OF VITAMIN A
BETA-CAROTENE
+2
15,15' DIOXYGENASE
RETINAL
H
–1
DEHYDROGENASE
RETINOL
OH
RISK ALLELE
G
AT rs 11645428
• VITAMIN A DEFICIENT
MORE OF...
• CARROTS
• SQUASH
• AVOCADO
• FISH
• PEPPERS
• EGGS

Student Wellness Initial Report 2017

DCGSAC Quality of Life & Wellness Survey | Spring 2017

Initial Summary

The Quality of Life & Wellness Survey was conducted in collaboration with partners in the Illinois Department of Clinical-Community Psychology. This work has been approved by the Illinois Institutional Review Board (#16690).

Goals

Psychological constructs (e.g., depression) were assessed using validated measures common in both research and clinical assessments

1) Assess the following in chemistry graduate students:
   - Wellbeing & Happiness
   - Depression
   - Anxiety
   - Social Support
   - Advisor Relationship
   - Satisfaction with Dept. and Research Area
   - Knowledge of Services (Mental and Physical Health Services, ISSS)
2) Use results to gain insight into the experience of chemistry graduate students and develop action items for DCGSAC.

Survey Response

Response rates for similar surveys range from 10-40%. Incentives were not used.

- Survey sent to all grad students in Chemistry (N = 275)
- 52% fully completed the survey (N = 145)
- Ratios for gender identity and race largely consistent with grad students in Chemistry.
- More representative of domestic students than international students (59% of domestic students complete the survey vs. 34% of international students).

Overall Results

Results collapsed across gender, international/domestic student status, and Research Area

- The majority of grad students responded positively regarding:
  - Overall advisor relationship (77%)
  - Satisfaction with advisor career (68%) and psychological (65%) support
  - Satisfaction with the department (65%) and their research area (75%)
  - Knowledge of campus physical (95%) and mental health services (82%)
- A meaningful number of grad students (2-34%) responded negatively (or strongly negatively) in these same areas
- A significant portion of students (~26%) expressed high levels of depression and/or anxiety.[1]

Gender Differences

- Women indicated significantly higher levels of social support as well as better knowledge of mental health services on campus.

International / Domestic Student Differences

- International students were significantly more likely to report higher ratings for:
  - Overall advisor relationship
  - Instrumental and psychological advisor support
  - Satisfaction with advisor career and psychological support

Research Area Differences

- Half (8/16) of the main measures demonstrated significant differences between Research Areas:
  - Happiness
  - Depression
  - Anxiety
  - Knowledge of physical health services
  - Overall advisor relationship
  - Satisfaction with advisor psychological support
  - Satisfaction with Department
  - Satisfaction with Research Area
- In 63% (10/16) of the metrics, Organic Chemistry demonstrated the poorest results – with 70% (7/10) of these results being statistically significant.
- Individuals in Organic and ChemBio reported the highest levels of depression and anxiety.

Student Services: Knowledge & Utilization

- Overall students reported a high level of knowledge for campus services (Mental and Physical Health, ISSS)
- Regarding mental health, of those who reported high levels of depression and anxiety only 39% have received mental health services in the past 12 months

Recommendations and Future Plans

1- Lipson, S. et al. (2016). Major Differences: Variations in Undergraduate and Graduate Student Mental Health and Treatment Utilization Across Academic Disciplines. *Journal of College Student Psychotherapy*, *30*(1), 23–41.

Analyses and report prepared by Michael Kruepke, M.A. (kruepke2@illinois.edu) on June 1, 2017

Department of Chemistry Graduate Student Wellness Report 2017: Overview

What is this report?

This report was created by DCGSAC in conjunction with the Department of Chemistry administration in response to the Graduate Student Wellness survey that was conducted during April 2017. The results are meant to inform students, staff, and faculty of the perceived issues the Department of Chemistry may have with regards to the mental health and well-being of graduate students.

What is the goal of this report?

The goal of this report is to share the findings of the Student Wellness survey, provide a list of resources for anyone seeking mental health help, and continue a dialog between the graduate students and faculty to improve the overall well-being of the Department of Chemistry.

How were responses collected and processed?

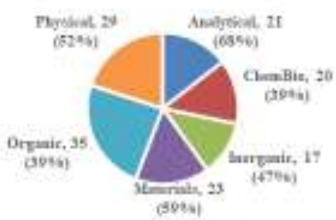
Responses were collected via an anonymous online survey administered by DCGSAC from April 12 to April 24, 2017. Raw data was received and analyzed by a clinical psychology graduate student assisting with this study in accordance with Institutional Review Board (IRB) #16690. The survey consisted of questions on topics such as happiness, health, depression, anxiety, advisor support, social support, etc.

What are the report outcomes?

This report is a joint effort between the DCGSAC Student Arbitration sub-committee and Department of Chemistry administration. The most significant (attention demanding) data presented in this report—those of the depression and anxiety scales—have led to an analysis of current graduate student mentoring by faculty and how to improve it as well as how more mental health resources can be provided for graduate students.

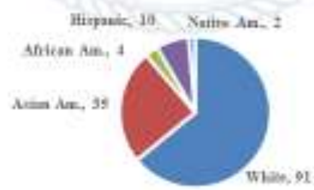
Survey Demographics

Respondents by Area (% of total students in area)



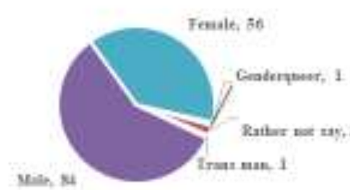
Department at large:
Analytical: 31 ChemBio: 51
Inorganic: 36 Materials: 39
Organic: 89 Physical: 56

Respondents by Race/Ethnicity



Department at large:
White: 166
Asian American: 79
African American: 6
Hispanic: 20
Native American: 3
Unknown: 28

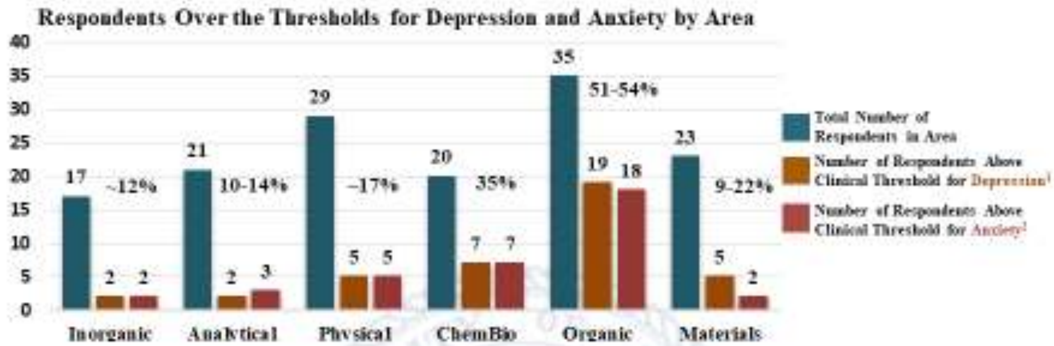
Respondents by Gender Identity

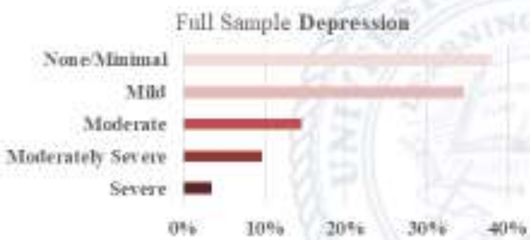


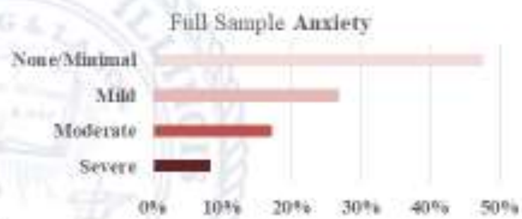
Department at large:
Female: 108
Male: 194

Department of Chemistry Graduate Student Wellness Report 2017: Trends from Survey

Trends from Multiple Choice Questions







Recommended Action for Given Severity of Depression or Anxiety[3]

None/Minimal: No treatment   Mild: Watchful Waiting   Moderate: Consider therapy and/or pharmacotherapy
Moderately Severe: Active therapy and/or pharmacotherapy   Severe: Immediate initiation of pharmacotherapy and active therapy

References: 1. Kroenke K.; Spitzer R. L. The PHQ-9: A New Depression Diagnostic and Severity Measure. *Psychiatric Annals* **2002**, 32, 509-521. 2. Spitzer, R. L.; Kroenke, K.; Williams, J. B.; Löwe, B. A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. *Archives of Internal Medicine*, **2006**, 166, 1092-1097. 3. Kroenke, K., Spitzer, R. L., Williams, J. B., & Löwe, B. The Patient Health Questionnaire Somatic, Anxiety, and Depessive Symptom Scales: A Systematic Review. *General Hospital Psychiatry*, 32, 345-359.

Trends from Free Response Questions

Mental Health Information and Access

Participants strongly desired more information on mental health services on campus. A more thorough and consistent presentation of services and information is desired including occasional seminars by outside professionals.

Representative quote: "Make it more clear how to access mental health services. You really have to want to utilize these resources to be able to find information..."

Department of Chemistry Graduate Student Wellness Report 2017: Survey & Next Steps

Trends from Free Response Questions Continued

Training for Advisors/Mentors

Many participants felt their advisors had not received enough formal training in being effective mentors, or in approaching a student about mental or physical wellness concerns in a productive fashion.
Representative quote: "In some cases, [faculty] try to motivate students by insulting them, creating hostile lab environments, being passive aggressive, and other damaging tactics."

Lack of Accountability for Advisors

A perceived lack of accountability on the part of the PIs was common. Some students felt their concerns could not be effectively voiced without fear of reprisal.
Representative quotes: "Faculty have too much power over their students and there is no system in place to stop advisors from mentally and emotionally abusing their students..." "My committee doesn't seem to be invested in guiding my education. Professors have either not been present or disengaged for events such as my literature seminar or prelim exam."

Recommendations & Future Department Actions

Graduate Student Mental Health:

In response to data showing at least 41 graduate students over the threshold for depression and/or anxiety, the Department of Chemistry will place more emphasis on ensuring graduate students have regular access to wellness professionals. This includes the establishment of a monthly time reserved for a graduate student support group run by a professional through the Counseling Center. PIs are highly encouraged to allow students time attend to these events as well as seek any other help they may need.

Further Training & Feedback for PIs:

The Department of Chemistry is seeking to implement new training for PIs with a specific focus on personnel management. The goal of the training is to help students and PIs address expectations and frustrations in a more productive manner. The department will also test two approaches for improved PI training and awareness of mental health: a campus expert on student mental health and related issues will be invited to faculty meetings on a regular basis. This has not been done in the past. In addition, the new Assistant Director of Graduate Diversity and Climate, who is in regular contact with students as an ombudsperson (an impartial intermediate), will prepare anonymized feedback for faculty, subject to approval from the students in contact. While a number of respondents were interested in a more automated feedback system, it creates concerns for anonymity when specific abuses or problems are mentioned by students online; these concerns can be avoided with an ombudsperson serving as an intermediate.

DCGSAC is committed to improving the quality of life of graduate students that feel unsafe, depressed, or anxious due to their work. We will continue to work with the Department of Chemistry administration to find workable solutions to these difficult issues that improve working conditions while maintaining the University of Illinois' commitment to excellence in chemistry.

Resources and Avenues for Further Feedback

Know your rights as a graduate student
UIUC Department of Chemistry Graduate Student Handbook:
https://chemistry.illinois.edu/system/files/inline-files/Grad_Manual_Fall_2017_final.pdf
The Department of Chemistry abides by the Graduate College's Policy and Procedures on grievances by Graduate Students. Please review section 8 of the graduate student manual.

UIUC Psychological Services Center http://www.psc.illinois.edu/
Our services include therapy, psychological evaluations, couples counseling, mindfulness training, conflict consultations and restorative circles.

Counseling Center https://counselingcenter.illinois.edu/
Helps students to address any academic, relational, and emotional concerns. The Center provides free counseling services.

The Mental Health Clinic at McKinley Health Center http://mckinley.illinois.edu/medical-services/mental-health
The Mental Health Clinic at McKinley provides evaluations, consultations, and recommendations for subsequent treatment for a variety of emotional and behavioral difficulties.

Champaign-Urbana Crisis line
217-359-4141

National Suicide Prevention Lifeline
1-800-273-8255

Office of Inclusion and Intercultural Relations https://oiir.illinois.edu/
Support of students of color, the LGBT+ community, and other underrepresented students. Offices include: Bruce D. Nesbitt African American Cultural Center (BNAACC), Asian American Cultural Center (AACC), La Casa Cultural Latina (La Casa), LGBT Resource Center (LGBTRC), Native American House (NAH), and Women's Resources Center (WRC)

Links to resources can also be found on the DCGSAC webpage

DCGSAC wants to hear from you! It is our job to represent your interests and we want to help get you the right resources for any non-research problems you may have. Less sensitive questions, comments, and concerns can be submitted via e-mail to chem-dcgsac@illinois.edu and anonymous questions, comments, and concerns can be submitted at https://illinois.edu/sb/sec/6498680 (a netID is required to log in to WebTools, but the submission is anonymous).

Flyer for 2018 Summer Lecture Series

Flyer for 2019 Summer Lecture Series

Annotation Guidelines

I. DEFINITIONS

For the purpose of this assignment, we define empathy broadly as *the ability of people to recognize and respond to the emotions of others*.

Two different kinds of empathy reveal the ways we are able to relate to a friend/family/co-worker/patient in crisis. These are:

1. Cognitive Empathy:

- is *largely a conscious drive to recognize and understand another's emotional state* (i.e., simply put: knowing how the other person feels and what they might be thinking.)

- idea: recognizing and placing ourselves in someone else's situation to gain a better understanding of his/her experience.

Example: In moments when someone is hurting, it can be easy for us to maintain a distance from it so we can see the big picture. E.g.: if a friend doesn't get a job they interviewed for, you can most likely see their disappointment. However, you may also recognize that your friend is talented and will likely find a great job soon. Moreover, when we are practicing cognitive empathy, we can meet people where they are and understand why they would be feeling sad or disappointed after not getting the job. We practice imagining what it might be like to be them at that moment, looking at the situation or circumstance from their perspective.

2. Affective Empathy:

- the capacity to experience an appropriate emotion in response to another's mental state. (although we cannot measure the actual "capacity", it may be inferred based on the context)

Example: Imagine sitting close to somebody you care about (i.e., your child, sibling, or close friend, etc.) who is sad or begins to cry. What they are experiencing likely has an impact on you: you might begin to feel sad as well. When we experience affective empathy, we are moving from cognitive empathy into a shared emotional experience.

More examples of text indicating both cognitive and affective empathy (below is an excerpt from a physician's reflection of a dialogue with a patient.):

The patient definitely seemed worried and a bit scared when he heard about his diagnosis. I too felt sad to be breaking this news to him and even though being a physician many times involves breaking this kind of news to patients, it is never easy.

Basic Discourse Unit of Representation (i.e., how to highlight empathic text):

Once you found a portion of text you think indicates empathy do:
1) identify and underline the anchor(s) (ie., the word(s)/phrase(s), etc. that indicate empathy);
2) highlight the sentence that contains the anchor;

Examples:

1. *Anxiously, she nodded.*
2. *I was nervous.*
3. *I was ecstatic to hear her willingness.*
4. *I vividly recall her eyes welling with tears.*
5. *I knew that Betty was very shocked.*
6. *I realized that she was nervous for her results.*
7. *Her tone throughout the conversation was a bit guilty and shameful.*
8. *She seemed nervous.*
9. *When I first saw Betty outside in the waiting room, I smiled at her and then went into my office as I prepared myself one last time because admittedly, I was nervous and I knew I had to have a positive attitude so Betty would not panic too much.*

Positive example of Empathy:

Affective Empathy:

1. *I was ecstatic to hear her willingness.*
2. *Betty seemed sad about her diagnosis, and honestly, it made me feel a bit sad as well.*
3. It is worse with telling somebody who has cancer that they might die because you have to help them go through the process of accepting their fate. This is hard for a professional too since they are a person and have emotions. (348, 6)

Cognitive Empathy:

1. *She was nervous,*
2. *I knew that Betty was very shocked*
3. *She didn't look too well, and the shock must have hit her hard,*
4. *I saw how torn and devastated Betty really was.*
5. *She had chosen to ask her family to leave and talk to me in private.* [SHOWS EMOTIONAL STATE OF PATIENT]
6. *"Yes, I'm fine doctor. Please tell me what is going on", she responded agitated.*
7. *She didn't really express much emotion at this time as she hadn't really seen this as a big deal as long as it could help her get better.*
8. The doctor wanted to take the weight off of the patient's shoulders. (Idiomatic phrases)
9. The doctor watched the patient come back down to Earth. (Idiomatic phrases)
10. She seemed not shocked by this information but very nervous. (it's ok if doctor is not 100% sure of their perception of the patient's emotional state)
11. A few minutes passed by and I asked her how she was feeling. She said she was a little confused and wanted to know if this can be fixed.
12. Overall, she did not take the news horribly. (Describing some emotional state by stating what the patient isn't)
13. She did not take this news poorly, instead she seemed as if she was expecting it. Describing some emotional state by stating what the patient isn't)
14. I smiled at them in a friendly way to let them know that they could be open with me and to try to calm them down a bit. (319, 6)
15. Knowing that there is a plan in place, and she understood what she needed to do to get healthier and rod of her chest pain, she was encouraged. (350, 6) (In this scenario the doctor recognizes the patient's mental state.)

False-Positive Examples:

Cases that might look like cognitive or affective empathy, but they are not.

1. ***Sympathy is NOT Empathy:***

Sympathy is feeling compassion, sorrow, or pity for the hardships that another person encounters.

Examples:

I tried to be as sympathetic as possible.
I felt sorry for him.
I had to inform him that we found that he unfortunately had stage three colon cancer.

2. ***Various forms of care are NOT Empathy:***

Example:

I did this in hopes to put her at ease.
I made sure we had privacy in order for Betty to be as comfortable as possible.
I greeted her with a hug and guided her to sit in the chair in front of my desk

3. ***Doctor's recollection of the patient stating their emotion without the doctor's processing of those emotions, do not count as empathy.***

Example 1: "Yes that is correct, which is why I'm worried why this is all of a sudden happening to me." She said. (essay 060)

Example 2: She nodded in understanding so I continued on with my spiel. (essay 172)

4. ***The doctor's recognition of the family members' emotional and cognitive state does not count as empathy for our purposes.***

Example 1: "Her spouse was worried about the idea of high cholesterol, knowing it is a bad thing to have in the body" (essay 057, Batch 03).

Other Negative examples of Empathy (with explanation in brackets):

1. *I mentioned to not give up hope* [ENCOURAGEMENT]
2. *I made sure they had a sense of a support system* [OFFER/ACCESS TO SUPPORT SYSTEM]
3. *I made sure to reassure her that I will help her through the process and make sure that everything is okay.* [OFFER/ACCESS TO SUPPORT SYSTEM]
4. *I assured her that as long as she undergoes the correct therapy, she could still bring her cholesterol levels back down.* [DOC'S REASSURANCE; NOT EMPATHY]
5. *I first reassured her that she is going to be fine* [DOC'S REASSURANCE; NOT EMPATHY]
6. *I tried to simplify the information to her* [MAKE PROCESS EASIER; NOT EMPATHY]
7. *I let her know that she was able to still get control of her body* [DOC'S REASSURANCE; NOT EMPATHY]

II. ASSIGNMENT INSTRUCTIONS

Identify and highlight instances of empathy in the essay. You will have **three** labels to use:

- Cognitive Empathy
- Affective Empathy
- Other

Part A - Labelling

You will use highlighting as a way of assigning labels. For instance, as in the above example, highlight portions of text that you believe show cognitive empathy in yellow. Similarly, you should highlight the portions that you believe show affective empathy in green. As you work through this process, you might run into instances that you believe carry some kind of empathy content that isn't captured by either cognitive or affective empathy. These grey-area instances should be highlighted in grey. Make sure to use the 'highlight' function in Word and not the 'shading' function.

Part B - Commenting

For each annotation label that you assign (by highlighting the text in any of the 3 colors), enter a comment in the text and explain your reasoning for choosing the label as such. You may do this by using the "New Comment" feature from the Review tab in Microsoft Word.

Part C - Overall Empathy Score

Label the entire essay with the 5-point score below. Place this score above your **Discussion** in the following format: **"Overall Empathy Score: X"**

Include a sentence of justification of your thought process for assigning the empathy score that you did.

1 very slightly or not at all
2 a little
3 moderately
4 quite a bit
5 extremely

Part D - Discussion / Notes

In a paragraph or two, discuss your findings and your general experience during this annotation process. We are not looking for a mere summary of the labels and comments already assigned. **Please append this to the end of the essay and title it "Discussion".** Submit your annotated essay into the "Submit ##_FL" folder in your individual text annotator folder with the file name "###_essay#_chemXXXXXXX_annotated"

Sample Annotated Essays

Sample Annotated Essay #1

I walked into the room where Betty was waiting to hear her diagnosis. She sat on a chair in the corner of the room and looked at me expectantly as I closed the door behind me. I asked her how she had been lately with regards to her chest pain as well as just in general. Betty said that the pain was the same and that she and her family were doing well. I proceeded to inform her that we had the results of her bloodwork. Betty's expression shifted to one of concern as she leaned forward in her seat and asked me what the problem was. I told her that the tests indicated that her cholesterol levels were dangerously high. Betty stood up looking panicked. She asked me what I meant by "dangerously" and if she was going to be hospitalized. I quickly reassured her that she's not in any immediate danger and that she didn't need to go to the hospital. Betty calmed down then, expressing relief at having a diagnosis and an eagerness to treat it.

Betty then asked me how she can reduce her cholesterol levels. I told her that the first thing we'll do is put her on statin therapy. At her look of confusion, I explained that statins are just medications that inhibit the activity of an enzyme involved in the process of producing cholesterol. Betty nodded her head, seeming to understand. I then added that regular exercise and a healthier diet could provide immense benefits to her as well. Betty lamented that while she always wanted to eat better and start exercising, taking care of two young children used up most of her time and energy. I reminded her that even small changes can make a huge difference. I recommended that she walk at least a few miles a day and add more fresh fruits and vegetables to her diet. In addition to this, I advised her to lower her intake of salt and saturated fat. Betty smiled and said that it seemed doable and that she was excited to finally start improving her health.

I think that in the moments before the doctor walked in, Betty was likely feeling anxious about her test results. I would imagine that her having no family history of heart disease may have reassured he a little, but not much. When the doctor entered the room and asked her how she was, she was probably just wanting to hear the test results and skip the obligatory small talk. After being informed of her high cholesterol levels, Betty felt distraught. She had a family, young kids to worry about. She likely wondered if she could still be a good mom/wife with a dangerous health condition. After the doctor reassured Betty that she was in no imminent danger and that there were effective treatments available, she felt more relaxed and determined to fix the problem. When the doctor informed Betty that she required statin therapy, Betty likely felt some anxiousness coming back. Not knowing what "statin" meant and the word "therapy" often entailing a lengthy and complicated process, it's not hard to see why her immediate reaction would be negative. However, the doctor gave her a brief description of what statin therapy is and how it works, clarifying the situation and bringing her some relief. Finally, the doctor recommended improving upon Betty's diet and exercise habits. This worried Betty because her two children are her priority, and she feared that making time for exercise and properly preparing fresh food would not be possible. Here, the doctor reassured Betty that even small changes would be effective for her, thus making her feel more capable and optimistic about the treatment.

Overall Empathy Score: 5
Justification: While there is no affective empathy, this text has a ton of cognitive empathy. It's everywhere.

Discussion:

- This doctor exhibits cognitive empathy everywhere and pretty much constantly, especially in their recap.
- A grey are is for reassurance, if the doctor tries to reassure the patient it’s typically not empathy, but if the patient feels reassured, is that cognitive empathy?
- Traces Betty’s emotional state as it is constantly changing.

Sample Annotated Essay #2

While walking back into the patient room that Betty was staying in, I smiled and it gave her a sign of relief. I went on to explain that while I am worried about these results, there is time and stuff that can be done to prevent any more damage to be done on herself. Betty was confused, but relieved, she asked what the results showed. I told her that she has dangerously high cholesterol, and that is what was causing her chest pain. I went on to explain that the reason for her chest pain is because she has very low-density lipoprotein (LDL) levels. This was causing a blockage for blood to reach her heart. I asked about her diet over these past couple of years because she has young kids. She explained that her diet has been pretty bad because she is so busy focusing on her kids and making sure she gives them the best upbringing she can and that while her kids have been eating healthy, she has not been doing the same, but has recently been changing that because she realized how much her kids look up to her. I told her that's it's very good to hear because one of the things she can do is eat healthier and get more exercise, so to hear her already changing one of her habits at her own will means a better success rate.

I went on to tell her that because he levels were so high, her chance of getting heart disease, diabetes, and other heart related issues was still very high and that she will be put on medication to control her cholesterol levels. The medication she will be on is a statin therapy. I asked her about other medications she's on and her alcohol consumption. She said she's not on other medications and has never been much into alcohol. I told her that she can drink, but a minimal amount and that the same goes for grapefruit juice because there are chemicals in grapefruits that will break down the statins.

She began to look more worried and asked her risk for heart disease and whether or not she will be taken from her kids. This was a hard question for me to answer because every person is different in their own ways. I told her that chest pain doesn't happen often, and can lead to death, BUT she has already started taking measures for her health by eating healthier. I went on to explain that no one in her family has a history of heart disease, so it's a good sign that her body will be able to heal itself from this health implication. Since she made the right move to talk to me (her practitioner), she is getting the help she needs.

I reminded her that high cholesterol is not something to play around with, and if she wants to get better, she has to be serious about getting better. Her spouse and children are the motivation for her to keep breathing and follow through with healthier eating habits and ensuring she gets enough exercise to keep her blood moving, but not to push herself too hard. I also told her that she needs to take the statin every day at close to the same time to keep the medication going through her leveled. Her not having any family members with a history of heart problems is a great sign that things will work out for the better. She asked me how long she'll have this issue for; I told her it could vary because the level is so high, but that she will set an appointment every six weeks to make sure everything is going smoothly and her levels are declining and she'll stop when her LDL declined to a safe and normal range. I warned her that some side effects are muscle pain, liver damage, and increased blood sugar, and that if she has any of these problems to not stop taking it, but to call me and see if she should take a break, change the statin, or if there needs to be a dosage change.

I create her prescription of statin to her desired pharmacy and we discuss a time for her to come back in six weeks. Knowing that there is a plan in place, and she understood what she needed to do to get healthier and rod of her chest pain, she was encouraged. Betty thanked me, and we carried on with our days.

Overall Empathy Score: 2
Justification: I found three instances of cognitive empathy and no affective empathy. Overall the essay was explanations.

Discussion:

- The doctor included a decent amount of cognitive empathy.
- She was confused, relieved, worried and encouraged.
- The doctor traces Betty's changing emotions well throughout the essay and picks up on Betty's state when she is expressing two emotions at once.

Sample Annotated Essay #3

I recently had a 32-year-old patient that was diagnosed with extremely high cholesterol and required treatment in order to control it. I had to break the news and explain her next steps, which meant therapy and a lifestyle change. My focus on that appointment was to break the news in the most ethical and gentle way while making sure that she fully comprehends the severity of her diagnosis. Before bringing her in, I made sure to make sufficient research so that I would be able to answer any questions. I also came up with a list of additional websites and printed out pamphlets so that she could have extra information.

I brought her in for a followup to explain her diagnosis, but before I started, I asked her some general questions about her current emotional and mental well being. I believe that any information I give out needs to be catered to the mental headspace that the patient is in. When she told me that she was <u>feeling well but a bit nervous</u> about the results, I assured her that she was not in grave danger and everything is fixable. I asked her what approach she would most be okay with, and once she let me know that she wanted to find out as much as possible, I made sure that both of us were comfortable enough to have a long discussion about her diagnosis.

I started off by letting her know that <u>I was concerned about her</u> cholesterol levels. I explained the difference between HDL and LDL and how one of them is healthy cholesterol versus unhealthy cholesterol. After testing her cholesterol levels, I noticed a high amount of LDL levels, which meant that in order for her to continue living a healthy life, there would need to be some changes. After answering her questions about cholesterol, I asked her if she was ready to discuss treatment options. She <u>needed a moment so I stepped out for a second</u> and once I came back, she was ready to talk about treatment. First, we discussed statin therapy, where I explained that it was just a simple medication to lower LDL levels which have few side effects for most patients. I explained that on the off chance that she has unusual side effects, I will schedule routine checkups <u>so she doesn't worry any more than she has to</u>. We also discussed ways to help improve statin therapy by eating more well-rounded meals and exercise more.

We decided to create a month-long schedule on how she will incorporate working out and healthy eating along with her statin therapy. I could feel her <u>getting nervous</u> about the time commitment, so we found an app on her phone to help remind her about her pills and daily workouts. I ended the meeting by asking what I could do to make sure that she was most successful with this routine. She <u>had some worries</u>, as usual, but decided that her husband could help support her so that she didn't stray away from her routine.

This <u>was an extremely hard appointment for both of us, as breaking the news to someone is never easy</u>. However, I believe that we had gotten to a point where I gave her enough tools and skills to pursue the next steps without me. I prepared her for the possibility of adverse side effects by giving her my cell phone number in case she had any life-threatening questions or extreme worries. I believe that this appointment was successful.

Overall Empathy Score: 5
Justification: This was one of the most empathetic essays we have read up to this point. The doctor was very empathetic overall showing a lot of both cognitive and affective empathy.

Discussion:

- At the beginning there were many instances that I could have highlighted grey, but it all just showed a lot of care and overall concern for Betty.
  - A lot of acknowledgements about both of their headspace and emotions and comfortability overall on a broad note.
- Overall lots of cognitive and affective empathy. See comments for more detail.